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TJD
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LOCOMOTIVE MANAGEMENT

BREAK-DOWNS AND THEIR CURES

INCLUDING A STANDARD SET
OF EXAMINATION QUESTIONS

By DONALD R. MACBAIN

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Examinations for Promotion, and
Studies on Mallet Compounds
and Electric Head-Light.

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TJD
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PREFACE.

This book, first published in 1900, and now in 1917, revised and brought up to date, is dedicated to the well-being of the engineers and firemen of this continent.

It will be well to remember, however, that in examinations for promotion, a candidate is usually required to show an examiner that he knows what he is talking about.

Therefore, when studying this little book, if a student finds an answer to some required question, he should use that answer as a guide, and take the first opportunity to prove its correctness.

Repeating a memorized answer, parrot-like, to an examiner, is a dangerous thing to do, especially when a man's whole future depends on his passing some required examination.

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PRELIMINARY LESSONS FOR BEGINNERS

Question 1. What is coal, and how many kinds are in use on American locomotives?

Answer. It is mineralized vegetation, and there are four kinds used, namely, anthracite, semi-bituminous, bituminous and lignite. The anthracite is commonly called hard coal. The semi-bituminous is such coal as the Pocahontas of old Virginia and the New River of West Virginia. The bituminous is called soft coal, and the lignite is found mostly in western states.

Q. 2.—How do they differ in composition?

A. The anthracite contains about 85 per cent fixed carbon and 5 per cent gas or hydro-carbons. The semi-bituminous contains about 75 per cent fixed carbon and 18 per cent gas or hydro-carbons. The bituminous contains 55 per cent fixed carbon and 30 per cent gas or hydro-carbons. The lignite contains 45 per cent fixed carbon and 35 per cent gas or hydro-carbons.

Q. 3.—What kind of coal is most generally used on locomotives, and what is its average composition?

A. Bituminous coal; and the chemical analysis shows composition as follows:

Water	3.15%
Gas	31.27%
Fixed Carbon	55.17%
Ash	10.41%
Total	100.00%
Sulphur	1.26%

Q. 4.—What is the process of combustion?

A. The chemical union of fixed carbon or hydro-carbons and oxygen, making a substance called carbon-dioxide (CO_2).

Q. 5.—What must be done to cause combustion?

A. The fixed carbon and air must be heated up to 3200 degrees Fahrenheit to have them unite, and the hydro-carbons and air must be heated to 1800 degrees Fahrenheit to do the same thing.

Q. 6.—Then what is the best temperature to maintain in a firebox?

A. 3200 degrees Fahrenheit or more, which will burn both the gases and the fixed carbon.

Q. 7.—How much oxygen does the fixed carbon and hydro-carbons need for perfect combustion?

A. Two parts of oxygen to one of carbon or hydro-carbon, which makes a chemical composition known as carbon-dioxide.

Q. 8.—How much air is required to burn one pound of carbon?

A. About 150 cubic feet, or twelve pounds.

Q. 9.—Is air composed entirely of oxygen?

A. No. It is largely composed of nitrogen, and has only about 20 per cent of oxygen.

Q. 10.—That being true, then how much air is required to burn one pound of coal?

A. In actual practice, about 300 cubic feet of air.

Q. 11.—What would happen if only one-half enough air is provided for the carbon?

A. The result would be imperfect combustion, and carbon mon-oxide would result therefrom.

Q. 12.—Does imperfect combustion of fixed carbon produce black smoke?

A. No.

Q. 13.—Is imperfect combustion of hydro-carbons accompanied with black smoke?

A. Yes; because the unconsumed napthalene, resins, etc., contained in the hydro-carbons pass off as free carbons or lamp black.

Q. 14.—What is a heat unit, commonly designated a B. T. U. (British Thermal Unit)?

A. It is the amount of heat necessary to raise one pound of water at 39.1 degrees Fahrenheit one degree, or to 40.1 degrees Fahrenheit.

Q. 15.—How many heat units in coal?

A. As one pound of pure carbon contains 14,500 heat units and one pound of pure hydrogen contains 62,000 heat units, the number of heat units in one pound of coal depends on the amount of both carbon and hydrogen in the coal. The best anthracite contains about 14,000; the semi-bituminous 15,000; the bituminous 13,000 and the lignite 11,000.

Q. 16.—What is steam and how is it produced?

A. At atmosphere pressure, when water is raised to more than 212 degrees Fahrenheit, it passes into a vapor called steam, and when confined in a closed vessel like a boiler its rapid vibration is known as steam pressure. As more heat is applied its vibrations become more wide, rapid and violent, hence we say the steam pressure is raised.

Q. 17.—What is saturated steam and what is its temperature at 200 lbs. pressure?

A. Steam generated and confined in the same vessel with the water from which it comes, and it has a temperature of about 387 degrees.

Q. 18.—What is superheated steam?

A. Steam that is taken from the vessel where it has been generated and passed through pipes placed in large flues in a boiler which subjects them to the heated gases passing from the furnace to the atmosphere. This dries the steam so that it has a temperature at 200 lbs. pressure of about 600 degrees Fahrenheit.

Q. 19.—Where is the heat obtained from to make steam in a locomotive boiler?

A. From the heat units contained in coal or other fuels.

Q. 20.—What is most desired in the burning of coal in a locomotive?

A. That it shall be consumed in such a manner that the greatest number possible of its heat units may be used and imparted to the water.

Q. 21.—How can this best be accomplished?

A. By maintaining a temperature of at least 3200 degrees Fahrenheit in the firebox, which means a white heat and almost entire absence of unconsumed gases, or black smoke.

Q. 22.—How can this be done by a fireman?

A. By using one, or at most two, scoopfuls of coal at a time, placing it along the sides and ends of the firebox and always on the whitest places in the firebox, because if large amounts of coal are placed in furnace at a time, the hydrocarbons are released so rapidly and quickly that there is not enough heated air to take care of them and they will pass away unconsumed.

Q. 23.—What will happen if too much coal is placed in one spot on the fire?

A. A clinker may form, shutting off that much of the air passage through the grates.

Q. 24.—How else can a clinker be formed?

A. By pulling a hoe or rake through the fire and drawing together the little fingers of clinker which are more or less present.

Q. 25.—What is the effect of the exhaust in the smoke box of a locomotive?

A. The steam jet entrains the gases from the front end on its whole circumference, and this entraining action ejects the gases of combustion from the front end rapidly enough to insure the necessary amount of draft.

Q. 26.—What appliances at the front end of a boiler known as the smoke box regulate the flow of air from grates to atmosphere?

A. The exhaust nozzle, deflecting plate, and adjustable apron, sometimes called a diaphragm. Increasing the size of exhaust nozzle opening decreases the flow of air. Decreasing the opening increases the flow of air, but also increases the back pressure on pistons in steam cylinders. Therefore, the nozzles should be as large as possible, consistent with good steaming. The deflecting plate forces all gases from flues in front end to pass downward to base of nozzle and then forward to stack through a wire screen which breaks up and retards live cinders. The adjustable apron is attached to bottom of deflecting plate, raising it causes fire to burn even over the whole grate; lowering it, fire to burn faster on front part of grates.

Q. 27.—What especial care must be given an exhaust nozzle other than its size and length?

A. It must be exactly plumb with center of stack.

Q. 28.—What part of the firebox should contain the most air?

A. The firebox nearest the place where gases last leave it should contain the best supply of heated air, because an atom of carbon may start from the back end of the firebox and unite with two atoms of oxygen, but on its way out, if it should pass over a bed of carbon which is breaking loose without a sufficient supply of oxygen to take care of it, one atom of the oxygen which had already united with carbon will break loose and fasten onto another atom of carbon, and the two molecules will pass out of the stack as carbon monoxide or imperfect combustion.

Q. 29.—About what depth of fire should be maintained in a locomotive firebox?

A. This depends on the grade of fuel used and the work being done, but four to ten inches of fuel should be enough.

Q. 30.—How must grates be handled?

A. As there are close to ten pounds of ashes in every hundred pounds of coal, and as ashes are non-combustible and if allowed to accumulate in box, will shut off air supply or melt into clinker, the grates should be shaken gently often enough to allow the ashes to fall into ash-pan or hopper, thus keeping a clean fire.

Q. 31.—What will happen if grates are shaken violently or opened too wide?

A. Holes will be torn in the fire and cold air will rush in and cause flues to leak, and also live fire will be dropped in ash receptacle, sometimes burning out a set of grates or grate frames.

Q. 32.—Does a small amount of water thrown on coal assist in the combustion of it?

A. Yes. Because besides laying the dust, it also soaks into the large lumps and when they are thrown on the fire the water turns into steam and its expansion opens up the coal to the fire.

Q. 33.—What important facts have been brought out in the preceding questions and answers?

A. The origin of coal.
Kinds of coal in use.
Composition of coals.
Kind in most general use on locomotives.
Chemical analysis of same.
The process of combustion.
The temperatures required.
Amount of oxygen required to burn coal.
The amount of oxygen in air.
The product of perfect combustion.
The product of imperfect combustion.
The cause of black smoke.
The value of a B. T. U. or heat unit.
The number of heat units in one pound of carbon.
The number of heat units in one pound of hydrogen.
The number of heat units in one pound of coal.
Steam and its composition.
Saturated steam and its temperature.
Superheated steam and its temperature.
The source of heat in a firebox.
How to fire coal to utilize all heat units.
Best method of placing coal on fire.
How clinkers are formed.
Effect of exhaust in the smoke box.
How the draft can be regulated.
Necessity of having nozzles as large as possible.
Place in firebox requiring best supply of air.
Proper thickness of fire.

Amount of ashes in coal.
How they can best be removed.
Damage caused by holes in fire.
A small amount of water on coal a help to combustion.

QUESTIONS FOR FIRST YEAR EXAMINATION.
MECHANICAL.

Question 1.—Do you devote a certain amount of time each week to study?

Answer. I have studied the best method of firing and have endeavored to inform myself regarding a locomotive.

Q. 2.—What do you consider essential to your success in regard to the use of fuel and supplies?

A. I feel that I must be as economical as possible in the use of supplies while performing the Company's work.

Q. 3.—What are the fireman's duties on arrival at engine-house previous to going out on a locomotive?

A. It is a fireman's first duty to report for duty at engine house, and on going to the engine, note first the water level in boiler and try same by both water glass and gauge cock. See that the fire is in proper condition and a full tank of coal and water. See that all proper firing tools are in place, lamps filled and cleaned and with markers in proper condition. Clean inside of cab, including boiler fixtures, and perform whatever other duties engineer may require.

Q. 4.—What is most important when preparing a fire before starting out on a run?

A. See that all holes are filled in fire, remove all clinkers and ashes from fire box, and make sure ash pan is properly cleaned.

Q. 5.—What is a steam gauge, and what does it indicate?

A. A clock-like arrangement with dials and hands to indicate steam pressure in pounds per square inch.

Q. 6.—On what principle does a steam gauge work?

A. There are two styles in use; one moves the hands on dial by the straightening out a partially round and flattened tube under the pressure of water inside. The other one is worked by means of a corrugated diaphragm against which the water presses, thus operating the pointer on dial.

Q. 7.—What is the purpose of water gauge glass and gauge cocks?

A. To show water level in boiler.

Q. 8.—What would indicate to you that the boiler connections of a gauge glass were becoming clogged?

A. The movement of the water in gauge glass would become slow, and water would not register in glass correctly with gauge cocks.

Q. 9.—What is a blower, and how should it be used when cleaning fire?

A. A pipe running from turret to front end of locomotive and terminating under base of smoke stack, allowing steam to pass from top of boiler through the stack, inducing a force draft. This apparatus is governed by a valve in the cab. Blower should be used whenever an engine is standing and injectors are being operated. It is also used to build up fire. At all times a blower should be used as lightly as possible.

Q. 10.—What is the purpose of a safety valve on a locomotive? Why is more than one used?

A. A safety valve is used to relieve the boiler of any pressure above the required amount. Two are used to insure safety; one is set at the maximum pressure and the other a few pounds above that pressure.

Q. 11.—What is an injector, and how are they designated as between those located below the running board and those above?

A. An apparatus for injecting water into a boiler whenever it is necessary. This is done by forcing a jet of steam into water, creating a movement, which, added to the steam pressure opens the boiler check and allows water to pass in. There are two kinds, designated as lifting and non-lifting. Lifting injectors are placed above the water level in tank and non-lifting injectors are placed below the water level in tank.

Q. 12.—Why is a locomotive supplied with two injectors, and why should both be kept in good working order?

A. A locomotive is supplied with two injectors, in case one becomes inoperative, or as it sometimes happens, both injectors are required to maintain water level.

Q. 13.—What is a lubricator, and what kind of oil should be used in it?

A. It is an apparatus to provide oil for steam cylinders both on the locomotive and air pump. A heavy, clean oil, known as valve oil, should be used.

Q. 14.—Why are grates made to shake, and how, when and where should they be shaken?

A. Grates are make to shake in order to remove dead ashes and clinkers from fire, and should not be shaken when passing over bridges, or switches, or near any place which may cause destructive fires.

Q. 15.—What is combustion?

A. Combustion is another name for burning. To obtain combustion we must allow the carbon and hydro-carbons of coal to mix with air properly heated. Hydro-carbons must have a temperature of at least 1,800 degrees Fahrenheit, and carbon should have a temperature of 3,200 degrees Fahrenheit. If the temperature of the air is raised to these same degrees, combustion will take place and the result will be what is known as carbon dioxide.

Q. 16.—What three important things are necessary for complete combustion of the coal?

A. First, enough air should be supplied for all coal to be consumed; second, this air must be properly mixed with the carbon and hydro-carbons, and, third, the air and coal must be heated to the required temperature.

Q. 17.—When is a fire considered to be in good shape?

A. A fire is considered to be in proper shape when it is of the right depth, with no holes or thin places in it.

Q. 18.—In what condition should the fire be in order that the best results may be obtained from the combustion of the coal?

A. The best results can be obtained when the fire contains sufficient coal to perform the work, and no more.

Q. 19.—How can fire be maintained in this condition?

A. The fire can be maintained in this condition by supplying just enough coal to provide for that which is being consumed and which is sufficient to do the required work.

Q. 20.—About how many pounds of coal does a No. 2 scoop contain? A No. 4 scoop?

A. A No. 2 scoop will hold about 17 pounds each and No. 4 about twenty-five (25) pounds.

Q. 21.—What is the effect of putting too many scoops of coal on a bright fire? Is this a waste of fuel?

A. The effect of putting too many scoops of coal on a fire at one time will have the effect of lowering the temperature of the fire and cause black smoke to issue from the stack. Any black smoke issuing from a locomotive stack indicates waste of fuel.

Q. 22.—What effect has the fire upon a scoopful of coal when it is placed in the firebox?

A. When coal is first placed on the fire the gases are driven off by the heat and ignite, causing a flame. After the gases are burned off and the temperature is raised, the coke takes fire and burns with a glow. Therefore, whenever a flame is seen in a firebox it is the gas burning.

Q. 23.—What is black smoke? Is it combustible?

A. Black smoke consists of unburned gas and small particles of carbon thrown off on account of imperfect combustion, and is not considered combustible.

Q. 24.—What effect on coal consumption has the practice of smokeless firing?

A. Smokeless firing usually means perfect combustion in the firebox, and certainly indicates economy in the use of fuel.

Q. 25.—Is the emission of black smoke objectionable, and what does it indicate?

A. Black smoke is considered a nuisance, and indicates poor methods of firing.

Q. 26.—How does a brick arch aid combustion?

A. A brick arch protects the flues from cold air drafts, acts as a buffer to catch melted clinker, and also forces the air to make a longer journey through the fire, before reaching the flues, and thus becoming more thoroughly mixed with the gases raised to the right temperature provides better combustion in the firebox.

Q. 27.—Can the firing be done more effectively if the water level is observed closely?

A. By ascertaining the level where an engine will carry her water and steam the best, and then maintaining that level as nearly as possible makes it possible for a fireman to do the best work.

Q. 28.—When operating the injector, what attention should the fire receive?

A. If possible, before operating the injector, fresh coal should be placed in firebox and allowed to ignite, in order to maintain boiler pressure against the operation of the injector.

Q. 29.—How would you take care of a boiler with leaky flues or firebox?

A. Keep your steam pressure up as nearly as possible to the maximum, and have bright fire underneath leaky flues or cracks in fire box.

Q. 30.—In approaching a steep ascending grade, how should the fire be regulated?

A. When approaching a steep grade, preparation should be made to ascend it by gradually building up the fire to a greater depth, in order to provide for the increased steam necessary.

Q. 31.—In approaching a long descending grade, how should the fire be regulated?

A. When approaching a descending grade, fire should be allowed to burn lightly until nearly the bottom of hill. Then fire should be built up again to normal condition.

Q. 32.—Does the fireman perform his whole duty when he "keeps her hot"?

A. A fireman does not perform his whole duty by keeping an engine hot. He should maintain the steam pressure as nearly the maximum point as possible without having her open safety valve, as it has been determined that an engine wastes about 15 pounds of coal for every minute the safety valve is opened. Also a fireman should try and prevent the safety valve opening, especially around stations, on account of the noise.

Q. 33.—What should be the condition of fire on arriving at a station where a stop is to be made?

A. Whenever it is known that an engine is going to stop at the next station, or at any point between stations, the fire should be allowed to die down so that steam pressure will not raise up as soon as engine throttle is closed.

Q. 34.—Where should the coal, as a rule, be placed in the firebox?

A. The coal should be placed, as a rule, along the sides and front and back ends of firebox, or at any part of fire where it seems to be burning brightest.

Q. 35.—How is the fire effected by a clinker? What causes clinkers? How can you best avoid their formation? How dispose of them?

A. The greatest cause for clinkers is too heavy firing, which prevents the air from passing freely to the flues and carrying off the melted particles of sand, or silica. This sand, in solution, was taken up out of the soil by the trees or plants when growing. When these trees or plants afterwards were turned into beds of coal they retained this same sand, and when it goes into a firebox and combustion takes place the sand goes into an impure form of glass, forming what is commonly termed a clinker. These clinkers can best be avoided by firing lightly, and at the same depth over the whole grate area, allowing the air to pass up freely and carry out the small atoms of silica or sand as fast as they are melted. The best way to dispose of clinkers is to either pull them up on top and fire around them, or if the engine is standing they can be pulled out through fire door or punched down through grate into ash pan.

Q. 36.—When and for what purpose is the use of rake on the fire bed allowable?

A. A rake should never be used on the fire unless it is absolutely necessary to spread enough fire to fill up holes, or it is necessary to get rid of clinkers. Pulling a rake through the fire will draw particles of melted clinkers together and thus make larger ones form.

Q. 37.—Within what limits may steam pressure be allowed to vary economically and why?

A. A steam pressure should not be allowed to vary more than five or ten pounds, as the lowering and raising of the temperature in the fire box causes expansion and contraction, which will eventually cause leaks.

Q. 38.—Why is it very important that coal should be broken so that it will not be larger than an ordinary sized apple before being put into the firebox?

A. Coal should be broken in order to reduce the air space between lumps, making it possible to carry a lighter fire than where coarser lumps are used.

Q. 39.—Why is it important that ash pan hopper lids be tightly closed and that care should be exercised not to fill hopper too full?

A. It is necessary that ash pan hopper lids be tightly closed to prevent the dropping of live coals along the right of way and thus be the means of destructive fires, and hoppers should not be allowed to fill up on account of the liability of burning out grate bars.

Q. 40.—At what temperature does water boil?

A. Water boils in an open vessel, at sea level, at a temperature of 212 degrees Fahrenheit. In a closed vessel the temperature at which water will boil increases in proportion to the steam pressure, and at 200 pounds pressure to the square inch it will boil at 387 degrees Fahrenheit.

Q. 41.—What is steam, and how is it generated?

A. Steam is water in its gaseous form, and is generated by raising the water above the boiling point.

Q. 42.—About what quantity of water should be evaporated in a locomotive boiler to the pound of coal?

A. About eight pounds of water should be evaporated in a locomotive to a pound of coal.

Q. 43.—What is the source of power in a steam locomotive?

A. The source of power in a steam locomotive is water raised to steam by means of combustion.

Q. 44.—What is a superheater as applied to a locomotive?

A. A superheater as applied to a locomotive is an apparatus for the re-heating of steam after it has left the boiler and before it is used in the cylinders.

Q. 45.—Why should an engine with superheater be easier to fire than one without superheater?

A. A superheated engine is easier to fire because the temperature of the steam is maintained at a higher temperature while being used, and therefore requires less coal.

Q. 46.—How should the water level be maintained in the boiler of a superheater locomotive?

A. The water level of a superheated locomotive should be maintained low enough so that particles of water will not be carried over into the superheated flues, thus lowering the temperature of the superheated steam.

Q. 47.—Do you understand coal furnished represents money invested, and should be fired economically and not allowed to fall out of the gangway?

A. Every pound of coal represents a certain amount of money, and any part of it wasted or lost means a waste of actual money.

Q. 48.—Is it objectionable to fill the tanks too full of coal, or spill water at standpipes or water tanks?

A. Coal should not be allowed to fall from tanks or gangways, and water should not be allowed to overflow at standpipes or water tanks, as water represents money as well as coal, and also causes ice to accumulate at undesirable places, and also washes away ballast.

Q. 49.—What are the duties of a fireman on arrival at the terminals?

A. The duties of a fireman on the arrival at a terminal is to leave his engine in as good condition, if not better, than when he took it.

Q. 50.—Is the engineman responsible for the fireman's conduct while on duty, and the manner in which the fireman's duties are performed?

A. The engineman, having the most responsibility and knowledge of a locomotive, does have control over the fireman's conduct while on duty, and the manner in which his duties are performed.

OIL BURNING LOCOMOTIVES.

Q. 51.—What is an oil burner as applied to a locomotive?

A. An oil burning locomotive uses oil instead of coal.

Q. 52.—How should the fire be started on an oil burning locomotive, and what precautions taken to prevent the back lash from the furnace?

A. If engine is at engine house where steam is available, a saturated piece of waste lighted can be thrown into firebox and atomizer started slowly, and oil regulating valve opened lightly. After fire has started the atomizer can be gradually opened wider until necessary fire is obtained. If at some outlying point where steam is not available, a wood fire can be carefully built in firebox and steam raised until a pressure of 20 pounds is obtained, which will also operate atomizer.

Q. 53.—Should an open light or torch be used in filling the tank of an oil burner, or to ascertain its interior condition or contents?

A. An open light or torch should never be used while tank is being filled with oil, or to ascertain conditions on inside of tank.

Q. 54.—What attention should be given the dampers?

A. Dampers should be opened just wide enough to admit the necessary amount of air required for combustion.

Q. 55.—What is the cause of the emission of black smoke from the stack, and how can this be avoided?

A. Black smoke from an oil burning locomotive is caused by too large a supply of oil and not enough air to provide perfect combustion.

FIRST YEAR EXAMINATION ON AIR BRAKES.

Q. 1.—What is an air brake?

A. An air brake is one operated by means of stored compressed air.

Q. 2.—How is the air compressed for use in the air brake system?

A. Compressed air for use of air brake system is obtained by means of an air compressor on engine.

Q. 3.—What arc the essential parts of the air brake as applied to a locomotive?

A. The essential parts of an air brake as applied to a locomotive are the pump, pump governor, main reservoir, engineer's brake valve, brake pipe line, triple valves, auxiliary reservoirs, brake cylinders, and brake rigging.

Q. 4.—How many kinds of triple valves are there in use?

A. There are two kinds of triple valves in use: Plain and quick-action.

Q. 5.—What is the main reservoir used for and where is it located?

A. The main reservoir is used to store air for the brake equipment, and is located at some point on engine.

Q. 6.—What does the red hand on each of the air gauges register?

A. The red hand on the large gauge represents main reservoir pressure and on the small gauge brake cylinder pressure.

Q. 7.—What does the black hand on each of the air gauges register?

A. The black hand on the large gauge represents equalizing reservoir pressure and brake pipe pressure on the small gauge.

Q. 8.—What is the usual standard brake pipe pressure?

A. The usual standard brake pipe pressure is 70 pounds on freight, and 110 pounds on passenger.

Q. 9.—What pressure is usually carried in the main reservoir?

A. The pressure usually carried in main reservoir is 130 pounds on passenger, and 90 pounds on freight.

Q. 10.—Why is it important that all air brake apparatus should be kept tight and free from leaks?

A. It is important that all air brake apparatus be kept tight and free from leaks to insure the proper working of the brakes and prevent waste of air, which means waste of coal and money.

Q. 11.—Where does the air come from that operates the sand blower, bell ringer, air signal whistle, waterscoop, fire door and other devices?

A. The air that operates the sand blower, bell ringer, air signal whistle, waterscoop, fire door and other devices is obtained from the main reservoir.

Q. 12.—How should the air pump be started?

A. The air pump should be started slowly with drain cocks opened.

Q. 13.—How is the automatic brake applied and released?

A. The automatic brake is applied by reducing pressure in brake pipe line, and brakes are released by forcing air back through brake pipe and charging auxiliaries.

Q. 14.—What are the different positions of the brake valves in use?

A. The different positions of the brake valves in use are as follows: The full release, running, lap, service and emergency, but when using the LT and ET equipments the brake valve has another position, known as holding. With straight air valves we have release, lap and application.

QUESTIONS FOR SECOND YEAR EXAMINATION.

MECHANICAL.

Q. 1.—What improvements have you made in your method of firing, and what better results have you obtained economically during the past year.

A. I have learned to be more economical in the use of fuel when firing.

Q. 2.—Describe the general form of a locomotive boiler? Of a firebox?

A. The general form of a locomotive boiler is cylindrical in shape, with front and back flue sheets, and tubes extending between them and fastened to flue sheets either by beading or welding. The form of a firebox is usually rectangular and is placed at the rear end of boiler so that the burning gases are carried forward through the flues and out of the stack at the front end.

Q. 3.—What is a wagon top boiler?

A. A wagon top boiler is larger at rear end of boiler over firebox and affords a larger space for storage of dry steam.

Q. 4.—How is a locomotive boiler supported? How is the difference in expansion between the boiler and frames provided for?

A. A locomotive boiler is supported on the frames by means of buckles which allows for the expansion and contraction of boiler and leg of boiler.

Q. 5.—What would be the result if the boiler were fastened rigidly to the frames at both ends?

A. If a boiler were fastened rigidly to the frames, the expansion and contraction would tear it loose in time.

Q. 6. What are the advantages of the wide type of firebox over the narrow firebox?

A. The advantages of a wide type of firebox are, that it allows for a larger grate surface, because it is placed above the frames and does not have to be drawn in like the old style of firebox. The fireman does not have to throw his coal so far, which tends to make his work more easy, and gives him a better opportunity to fire more economically.

Q. 7.—To what strains is the locomotive firebox subjected?

A. A firebox is subjected to the strains occasioned by expansion and contraction, also the pressure of steam per square inch within boiler.

Q. 8.—How are the sides and end-sheets of the firebox supported?

A. The sides and end sheets of a firebox are supported by rivets, staybolts and flues.

Q. 9.—What purpose is served by the small hole drilled in the outer end of the staybolts? How deep should it be?

A. The small holes drilled in the outer end of staybolts are known as telltales, because they show when staybolts are broken, as they usually break towards the outside end. Holes are drilled in end of staybolts about 1¼ inches deep.

Q. 10.—In what manner is a crown sheet supported?

A. A crown sheet is supported by radial staybolts or crown bars.

Q. 11.—How are the inside and outside sheets of the firebox secured at the bottom?

A. At the bottom of a firebox, inside and outside sheets are secured by means of a solid ring called a mud ring and are fastened by means of bolts passing through both sheets and ring and riveted on both ends.

Q. 12.—Why are boilers provided with steam domes?

A. Steam domes are placed on top of boilers in order to provide for dry steam when necessary to draw same from boiler.

Q. 13.—What must be the condition of a boiler in order to give the best results?

A. A boiler should be free from mud and scale and all joints steam tight.

Q. 14.—What is meant by circulation in a boiler?

A. Circulation in a boiler means the movement of heated water to the top allowing cold water to take its place.

Q. 15.—Give a practical definition of heating surface?

A. Heating surface in a boiler means any part of it exposed, to fire on one side and water on the other, such as flues, side sheets, end sheets and crown sheets.

Q. 16.—What would be the result if crown sheet became overheated?

A. If a crown sheet becomes overheated, either on account of lack of water or an accumulation of mud on same, it will become loosened at rivets and would be forced down from radial stays or crown bars, making it dangerous to life.

Q. 17.—What attention should be given to boiler attachments, such as water glass, gauge cocks, etc., and how should the water glass be blown out?

A. Especial attention should be given at all times to boiler attachments in order to know that water glass is registering with gauge cocks, and gauge cocks kept free from mud in order to show proper water level. In order to blow out a water glass, first open blow-off cock, then close water valve, then close steam valve and open water valve, then close blow-off cock and open steam valve last, and take notice that water glass indicates same level as gauge cocks.

Q. 18.—What is a boiler flue?

A. A boiler flue is a steel or iron pipe 1½ inches to 2 inches in diameter extending from front firebox sheet to flue sheet in front end of boiler. Boiler flues comprise the greater part of the heating surface of a locomotive boiler.

Q. 19.—What are the most common causes of leaky flues?

A. The most common causes of leaky flues are sudden changes of temperature caused by injecting too much cold water into a boiler at once, or allowing air to pass up through holes in the fire; also leaving firebox door open too long at a time.

Q. 20.—What is the purpose of placing the injector check valves near the front end of the boiler, or on top of boiler?

A. The purpose of placing an injector check near the front end of a boiler is to throw the water in where water is coolest in boiler. If water should be thrown into the boiler against side sheets of the firebox it would be liable to crack same.

Q. 21.—Name the different appliances in the smoke-box that regulate the draft through the flues?

A. The different appliances in a smoke-box to regulate the draft are, deflecting plates, diaphragm plate and exhaust nozzle. By increasing size of nozzle the draft is decreased. By lowering diaphragm plate the fire is made to burn faster near the front end of firebox. By raising same plate, fire is made to burn more evenly towards back end.

Q. 22.—What is the purpose of a netting in a smoke-box or front end?

A. Netting is placed in a front end with fine enough mesh to break up the sparks coming from the firebox to prevent them from passing out of stack and causing fires.

Q. 23.—What does it indicate when excessive fire is thrown from stack?

A. When excessive fire is thrown from stack it indicates holes in the deflecting plates or netting.

Q. 24.—What causes a netting to stop up?

A. Netting will sometimes stop up on account of being of too small a mesh; also coal being burned just enough to start the pitch and resin from it and making it stick will lodge in mesh of netting, and sometimes melted clinker will lodge and obstruct it.

Q. 25.—What object is there in having the exhaust steam go through the stack?

A. Exhaust steam is made to pass through the stack in order to cause a vacuum in front end which is filled by air rushing through fire, thus providing air for the combustion of coal.

Q. 26.—How does this affect the fire?

A. This provides a sufficient amount of air to burn the coal.

Q. 27.—What is out of place when the exhaust steam and smoke issue from one side of the stack?

A. When steam issues from one side of the stack it indicates that the exhaust tip is not plumb with the stack.

Q. 28.—What do you consider the best method of firing a locomotive?

A. Coal should be placed on fire in as small quantities as possible at a time. It should be placed along the side sheets and front and rear ends more than in the middle. However, a close watch should be kept of the condition of the fire at all times and coal placed on spots which show the brightest or the whitest color. Grates should be shaken occasionally to allow dead cinders to fall into ash pan so they will not obstruct the free passage of air into the firebox.

Q. 29.—What is the proper way in which a fire should be cleaned when out on the road?

A. The proper way to clean a fire when out on the road is to shake the fire just enough to allow dead cinders and ashes to drop into ash pan. If there are any clinkers in fire, they should either be broken up into small parts and pushed through grates or hook them out of firedoor and thrown out of gangway by means of scoop.

Q. 30.—Is it a waste of fuel to open the firebox door to prevent pops from opening? How can the necessity for this be prevented?

A. It is a waste of fuel to open firebox to prevent pops from opening. A better way to prevent engine from popping is to work injector, providing water level will allow. If engine is about to start soon, placing on fresh coal will deaden the fire temporarily.

Q. 31.—What should be done to prevent black smoke from trailing when the throttle is closed?

A. When throttle is closed suddenly and black smoke commences to trail, open the blower slightly. If engine is equipped with smoke consumer, turn that on just enough to stop black smoke.

Q. 32.—What is the principle on which an injector works?

A. There are three things which cause an injector to work. First, you must have atmosphere pressure on top of water in tender. Second, boiler pressure so arranged that it can go in back of water and balance pressure against boiler check. Third, steam passing into water which fills body of injector causing same to take on velocity and expansion which will eventually cause boiler check to raise and allow water to pass into boiler.

Q. 33.—What are the various parts of an injector?

A. The various parts of an injector are the body, steam nozzles, combining and delivery tubes, lifting tube and delivery tube, and the various valves to operate steam and water.

Q. 34.—What is the difference between a lifting and non-lifting injector?

A. A non-lifting injector is one placed below water level in tank, allowing water to flow to it by gravity. A lifting injector is one placed above water level in tank, making it necessary to cause vacuum in body of injector, which will allow atmosphere pressure in tank to force water into body of injector.

Q. 35.—Is it good practice to work both injectors when the engine is not working steam?

A. It is not good practice to allow both injectors to work when an engine is standing still, as such action will cause temperature of water to lower too fast.

Q. 36.—How would you prevent the waste pipe of an injector from freezing while the injector is shut off?

A. The waste pipe of an injector can be kept from freezing by allowing the overflow valve to be kept slightly open, which will allow a small amount of steam to pass through.

Q. 37.—How rapidly should water be fed to the boiler when hauling a train?

A. Water should be fed to a boiler in the same proportion that it is being converted into steam and used.

Q. 38.—How can the hose, feed pipe and delivery pipe be protected from freezing?

A. The hose, feed pipe and delivery pipe of an injector can be protected from freezing by closing the overflow valves and opening the steam valves on the turret slightly and have steam ram wide open, but care should be taken that water in tank is not heated too great, as it might prevent injector from working when needed.

Q. 39.—How are the valves and cylinders of a modern locomotive lubricated?

A. The valves and cylinders of a modern locomotive are lubricated by means of what is termed a sight-feed hydrostatic lubricator.

Q. 40.—What would be the result if the valves were not lubricated at all?

A. If the valves were not lubricated at all, the valves would become worn or cut, or the seat would become worn so that it would leak, and some parts of the valve gear might be broken.

Q. 41.—Should the oil be fed to the valves regularly or intermittently?

A. Oil should be fed in just the right amount and at regular intervals.

Q. 42.—Name the various parts of a hydrostatic sight-feed lubricator?

A. The various parts of a hydrostatic sight-feed lubricator are the oil reservoir and its filling plug and drain cock, condensing chamber with water pipe and water valve, oil tubes, equalizing tubes, choke plugs, regulating valves and sight feed glasses.

Q. 43.—How should a lubricator be shut off before filling?

A. A sight-feed lubricator should be shut off before filling in this order: First, sight-feed, then condensing valve and last steam valve.

Q. 44.—Is it good practice to fill a lubricator too full of cold oil? What should be done in the event of not having sufficient oil to fill the lubricator?

A. It is not good practice to fill a lubricator too full of cold oil as the expansion of it when becoming warm might burst oil chamber. If at any time there is not sufficient oil to fill lubricator, fill up with warm water.

Q. 45.—How often should a lubricator be blown out?

A. A lubricator should be blown out at least once a week or as often as water shows dirty in sight-feed glass.

Q. 46.—Why should steam valve on the boiler that supplies steam to lubricator be kept open wide when lubricator is in use?

A. The steam valves on the boiler, supplying steam to lubricator should be kept wide open in order to supply steam in lubricator to balance pressure coming back from steam chest.

Q. 47.—How long should the main steam valve at the fountain be opened before the feed valves are opened? Why?

A. The main steam valve on a lubricator should be opened about 15 minutes before the feed valves are opened, in order to allow water to condense in condensing chamber.

Q. 48.—In what order should valves on lubricators be opened?

A. The valves on lubricators should be opened as follows: Steam valve, then water valve, last regulating valves.

Q. 49.—Which is the better practice, to close the feed valves or water valve while waiting on sidings, etc.?

A. When waiting on sidings or standing still at other points it is the best practice to close feed valves instead of water valve.

Q. 50.—Does the drafts from the open cab window affect the working of the lubricators? Why?

A. The draft from an open cab window will sometimes cool off oil in lubricator and affect its working.

Q. 51.—When the run is completed, why should the feed valves be shut off at least a few minutes before the main steam valve is closed?

A. When a run is completed the feed valves should be shut a few minutes before main valve is closed in order to allow pipes to be clear of all running oil.

Q. 52.—How should headlights be filled and made ready for service?

A. Headlights, when being filled, great care should be taken not to fill them too full. Wick should be carefully trimmed and body of the headlight made clean and free from all waste or dirt that might cause a fire.

Q. 53.—What is the purpose of a steam heat regulating valve on a locomotive?

A. A steam heat regulating valve on a locomotive is used to regulate the flow of steam from the boiler to the train.

Q. 54.—What is important, with reference to steam heat regulating valve that the fireman should know before an engine is coupled to a passenger train to leave a terminal?

A. Before an engine is coupled to a passenger train, the fireman should know that the apparatus on the engine is in good working order, and that steam will pass freely out through rear coupling on tender.

Q. 55.—Is it important to know that the sand box is filled with clean, dry sand before leaving the terminal? Why?

A. It is sometimes necessary to use sand on a slippery rail to prevent engines from sliding. Therefore, it should be known at all times that a supply of clean, dry sand is on locomotive.

Q. 56.—What is the purpose of a bell ringer on a locomotive?

A. The purpose of a bell ringer on a locomotive is to relieve the fireman of its care and allow him to attend to other duties while bell is ringing.

Q. 57.—Describe an air bell ringer and how may it be adjusted?

A. A bell ringer is worked by means of a cylinder and piston. Air being admitted to the cylinder will force the bell upward and gravity will bring it in the opposite direction. It can be adjusted by means of an adjusting screw placed there for that purpose.

Q. 58.—What is a smoke preventing device as applied to a locomotive?

A. A smoke preventing device is applied to a locomotive by placing tubes around firebox, with openings in firebox large enough to allow steam from smoke consumer to pass into firebox inducing a current of fresh air which supplies enough to make perfect combustion in firebox, thus avoiding black smoke.

Q. 59.—How much water should be used in the boiler when an engine is given up at the engine house?

A. At least three gauges of water should be left in a boiler when leaving engine at engine house, or cinder pits, or any other point where engine is placed when given up by enginemen.

Q. 60.—When should the boiler be filled with water at the finish of a trip?

A. Water should be placed in a boiler while on the way from yards to engine house, after finishing trip, in order not to be compelled to fill up boiler after engine is standing still at ash pit.

OIL BURNING LOCOMOTIVES.

Q. 61.—How should indirect heater be used?

A. An indirect heater should be used just enough to heat oil in tank so that it will flow readily to atomizer.

Q. 62.—How should McLaughlin oil connection be blown out between engine and tender?

A. On every oil burner is placed a blow back pipe connecting superheater chamber with pipe passing to atomizer. Whenever it is necessary to blow out connections between engine and tender, first close regulating valve, open blow-back plug and keep valve on tender open. This will allow steam to pass back through into tank, blowing out any obstructions in same.

Q. 63.—How should the atomizer be operated?

A. The atomizer should be used as follows: First turn on oil from tender, open atomizer steam valve slightly and then open oil regulating valve slightly, but before this operation it is necessary to place lighted waste in firebox so that spray coming from atomizer will become ignited.

Q. 64.—How should the burner be blown out?

A. The burner on an oil burning engine should be blown out as follows: First close tank valve, open oil regulating valve and then open blow-back valve, which will allow steam to pass from superheater to supply pipe and to burner, which will blow out any obstruction in same.

SECOND YEAR'S EXAMINATION ON AIR BRAKES.

Q, 1.—Why is the present brake called the automatic brake?

A. The present brake is called an automatic brake because any reduction in brake pipe pressure will cause brakes to apply.

Q. 2.—What are the different types of locomotive brakes in use?

A. The different types of locomotive brakes in use are the Westinghouse, Standard Automatic, straight air and ET

Equipment; the New York Standard Automatic; LT Equipment and straight air.

Q. 3. Where is the compressed air stored?

A. The compressed air is stored in main reservoirs, auxiliary reservoirs, brake pipe lines and distributing valves or control valves.

Q. 4.—What are the several functions of the auxiliary reservoir, brake pipe, brake cylinder, triple valve, automatic control or distributing valve?

A. The auxiliary reservoir is to store air for working of piston in brake cylinders. The brake pipe carries the air from main reservoir back to triple valves. The triple valve allows air to pass to auxiliary reservoir, sets brakes and releases brakes. The brake cylinder sets brakes by means of brake rigging and shoes. The automatic control or distributing valve performs the functions of an auxiliary reservoir, triple valve and high speed reducing valve.

Q. 5.—Where does the pump deliver the air?

A. The pump delivers air to the main reservoir.

Q. 6.—Where does the main reservoir pressure begin and end?

A. The main reservoir pressure begins at the pump and ends at the engineer's brake valve.

Q. 7.—What is excess pressure?

A. Excess pressure is the pressure carried in the main reservoir above that carried in brake pipe line.

Q. 8.—Why is excess pressure necessary?

A. Excess pressure is necessary to insure the quick release of brakes on train.

Q. 9.—How should a brake be cut out?

A. By closing a cock in the cross-over pipe under a car and opening the bleed valve in the auxiliary reservoir.

Q. 10.—How should handle of cut-out cock stand when closed?

A. The handle of a cut-out cock when closed should stand parallel with the pipe.

Q. 11.—How should handle of angle cock stand when closed?

A. The handle of an angle cock when closed should stand at right angles with the pipe.

Q. 12.—What does line on end of plug cock indicate, regardless of position of handle?

A. The line on the end of plug cock, regardless of the position of the handle, indicates the flow of air.

Q. 13.—How should a brake be "bled" off?

A. A brake should be bled off by holding the bleeder on the auxiliary reservoir open long enough to allow the brake to "pop off."

Q. 14.—How does the admission of air to the brake cylinders retard a moving locomotive or car?

A. The admission of air to a brake cylinder forces piston out and this being connected with rods forces brake shoes against wheels, causing a friction that eventually stops them.

QUESTIONS FOR THIRD YEAR'S EXAMINATIONS MECHANICAL

Q. 1.—What are the duties of an engineman from the time he reports to the engine house to begin a trip until he has the engine coupled to the train?

A. The duties of an engineman after being called to go out on an engine is to first report for duty at engine house; post himself regarding bulletin board; register his watch; see that all work reported on engine has been done, which he can ascertain by inspection of engine; examine condition of firebox, regarding ash pan, grates, etc., giving especial attention to crown sheet, bolts and tubes; see that both injectors are in good condition, and try water glass and gauge cocks. Be sure that all tools allowed are on the engine. Inspect tender and see that water and coal is there. Fill out Interstate forms and turn them in; and see that all pipes are open, especially during winter time.

Q. 2.—What is a steam locomotive?

A. A steam locomotive consists of a boiler mounted on wheels, driven by steam cylinders, and provided with necessary mechanism to operate engine in either direction.

Q. 3.—What are the principal parts of a steam locomotive?

A. The principal parts of a locomotive are the boiler, firebox, cylinders, driving wheels, and steam chests, with the necessary apparatus to control valves.

Q. 4. What examination should be made after any work or repairs have been done on valves, brasses, etc.?

A. Whenever any work has been done on valves or brasses, engineer should examine same and see that brasses are keyed brass to brass, and that valves will move full length of seat backward and forward by throwing reverse lever as far as it will go in either direction.

Q. 5.—How should a locomotive be started to avoid jerks to train, and is unable to start train how should slack be taken? What signal should be looked for at time of starting?

A. A locomotive should be started slowly to avoid jerks. and pick up speed one car at a time. If it is necessary to take the slack, back up until the lost motion between the cars is all taken up and then start in such a manner that when one car starts it will assist in starting the next one; but before leaving station, he should look for an "all right" signal from the rear.

Q. 6. After a locomotive has been started, how can it be run most economically?

A. After a locomotive has been started, it can be run most economically by pulling the reverse lever toward the center of quadrant, and working with as short a travel of the valve as possible. Avoid slipping the driving wheels, and see that the water level is maintained in the boiler at the right point as nearly as possible.

Q. 7.—In event of the fire becoming clinkered and in bad condition, and the steam pressure beginning to fall, what should be done?

A. If a fire becomes clinkered and in bad condition, the steam pressure will begin to fall and the engine should be stopped and fire cleaned at the first opportunity.

Q. 8.—What are the duties of an engineman when giving up his engine at a terminal, and how should it be inspected?

A. The duties of an engineman when giving up his train at a terminal are to start from some given point on his engine and inspect it all around until he has reached this same place; see that the fire is in proper condition, and see that the necessary amount of water is left in the boiler. The throttle must be securely closed and reverse lever in center of quadrant with cylinder cocks open. All valves on the lubricator should be closed; injectors should be in such condition that in freezing weather they will not freeze. And on passenger engines, steam heat valve should be left slightly open; firebox and arch should be carefully inspected. On going to engine house, all work should be reported promptly. making out reports on proper Interstate inspection blanks.

Q. 9.—How can it be known whether a boiler is carrying the proper pressure? Also location of crown sheet?

A. A badge plate is placed on boiler head in the cab, which shows steam pressure allowed in that particular boiler; also the location of crown sheet is shown. By bringing engine up to a popping point, and noticing gauge, it can be determined whether engine is carrying pressure allowed.

Q. 10.—What is a most important duty of the engineer in the care of the locomotive boiler?

A. The most important duty of an engineer when caring for a locomotive is to see that the crown sheet is at all times covered with water when there is fire in the firebox; and to see that feed water is so supplied that the right water level is maintained in boiler; to see also that the steam pressure does not vary more than eight or ten pounds from the maximum pressure allowed.

Q. 11.—Why are boiler compounds, such as soda ash, etc., beneficial to boilers?

A. Boiler compounds, such as soda ash, etc., prevent scale from forming on the inside of the boiler by softening it up and thus making it possible for it to pass out when boiler is being washed.

Q. 12.—When boiler compounds are used, what is essential in the care of the boiler?

A. When boiler compounds are used for the purpose of keeping scale from the boilers, they should be washed at regular intervals in order to get rid of this dirt, commonly called "scale."

Q. 13.—What do you consider essential for engineers to report on boilers and boiler attachments?

A. It is essential that an engineer report all leaks in boilers and all boiler attachments, such as flues, staybolts, mud rings, washout plugs, leaky flues, cocks, water glass connections, siphon pipes, and steam gauges.

Q. 14.—Are rapid changes in boiler pressure permissible?

A. Rapid changes in boiler pressure should not be allowed, as the expansion and contraction will cause unnecessary leaks.

Q. 15.—Name the various drafting appliances in the smoke box or front end and state how changes can be made to affect the draft?

A. The drafting appliance in the front end of an engine are the exhaust nozzles, adjustable diaphragms, and deflecting plates. By decreasing the size of the nozzle, the force of the exhaust is increased. By increasing the size of the nozzle, the force of the exhaust is decreased. By lowering the diaphragm plate, the engine is made to burn coal more quickly in front end of firebox. By raising diaphragm plate, the fire is made to burn more evenly, including the rear of firebox.

Q. 16.—If steam pipes or nozzle base joints are leaking, what effect does it have on the fire and how should they be tested?

A. Should steam pipes or nozzle base joints leak in the front end of an engine, it will destroy the vacuum in the front end, and affects the steaming of the locomotive by not allowing enough air to pass up through the fire. Leaky steam pipes and nozzle base joints may be tested with water pressure in the engine house. Another way would be to plug the nozzle tip where the exhaust to the air pump is tapped into the saddle, and the angle cock on a train opened, and pump allowed to work when the steam will show up at the defective joint.

Q. 17.—Why is it important that there be no holes through smoke box sheets or front end, and none in the smoke box seams or joints?

A. There should be no holes through smoke box sheets or front end because any air allowed to pass into front end at that point will destroy the vacuum, caused by the exhaust steam from cylinders, and sufficient air will not come through fire to fill this vacuum, and the result will be that the fire will not get enough oxygen to form perfect combustion, and cinders accumulating in front end will catch fire.

Q. 18.—What is a water gauge shield, and why used?

A. A water gauge shield is an appliance placed around water glass to prevent injury to enginemen in case glass should break.

Q. 19.—What should be done if a safety valve spring breaks?

A. If the safety valve spring breaks, the water level should be watched very closely and an attempt made at once to clear the main track by getting in on siding. Then, if possible, the spring should be screwed down as far as it will go. If this does not answer, take the spring out and substitute a block of wood. Screw it down until safety valve is tight, then raise steam up to required pressure and proceed.

Q. 20.—Why are safety valves usually placed on the highest point of the boiler?

A. Safety valves are placed at the highest point in boiler in order to prevent water from passing out when they open

Q. 21.—What is a boiler blow-off cock, and what is its purpose?

A. The blow-off cock is placed at some low point in the boiler, usually the leg of the boiler, in order to blow out mud and sediment, and also is used to relieve the boiler when carrying too much water.

Q. 22.—In case the steam gauge became out of order on the road and did not register the proper pressure, what would you do?

A. If a steam gauge should become out of order on the road, it will then be necessary to depend on the safety valves, and gauge should be reported on arrival at end of run.

Q. 23.—Why not try the water glass gauge by simply opening the drain cock?

A. Opening the drain cock of a water glass would not be a sure indication that cocks are open.

Q. 24.—Describe the principle on which an injector works, and what are its principal parts?

A. The principle on which an injector works is as follows: On lifting injector, steam is first allowed to pass through the overflow pipe which creates a vacuum in body of injector and pipes leading to boiler check. The pressure of the air on top of the water in the tank forces water up and fills body of injector and pipes leading to boiler check. By opening the steam ram, steam, is allowed to flow from turret into the rear of water in injector, and when it passes through the combining tubes into the water, it not only heats the water up to an expanding point, but imparts a velocity to it, and allows water to pass into the boiler, by forcing boiler check open.

The principal parts of an injector are the delivery nozzle, lifting nozzle, steam nozzle, and condensing nozzle.

Q. 25.—What is necessary that any injector may work properly?

A. In order that an injector may work properly, there should be a sufficient amount of water in the tank and no obstruction between it and injector; water should not be too warm, and injector and all tubes should be free from any obstruction: boiler check must also have sufficient lift.

Q. 26.—Give some of the common causes for failure of injectors to work.

A. Causes for failures of injectors are boiler checks out of order, combining tubes loose or obstructed, water too hot, hose lining worn so that particles of it enter combining tubes and valves, a coating of lime in tubes, manhole of tank not allowing sufficient air to flow in on top of water, and an inspirator may have an overflow packing nut leaking.

Q. 27.—How may it be determined whether the check valve or steam valve is leaking and what course should be pursued in case injector does not work?

A. If water and steam is coming from overflow, it indicates a check valve in boiler leaking, and if only steam appears, it is an indication that steam ram is leaking. If, from any of these causes, injector becomes too hot, overflow pipe should be closed and the hot water in injector blown back into tender; then waste valve should be opened and jet turned on. If this does not answer the purpose, cold water should be poured on body of injector from the outside until injector is sufficiently cool to allow its working.

Q. 28.—Suppose the locomotive was fitted with two injectors of the same make and size and the right injector was inoperative and the priming valve or steam valve broken on the left injector, what would you do?

A. If a locomotive is fitted with two injectors of the same make and size and both become inoperative, sometimes one good injector can be made from the parts of both by substituting from one to the other.

Q. 29.—What may be done if a combining tube is obstructed?

A. If a combining tube is obstructed, the steam bonnet of the valve can be removed and obstruction removed with a piece of stiff wire.

Q. 30.—What should be done in case of obstructed hose or strainer?

A. In case of an obstructed hose or strainer, close the waste valve and blow steam back through the hose into the tender. If this does not remove obstruction, then the hose must be taken down and cleaned.

Q. 31.—What should be done in case the feed water in tank is too hot?

A. In case the feed water in tank becomes too hot, cold water should be taken into tender as soon as possible, and if cold water is not available at once, boiler pressure should be reduced, as injectors will sometimes work with a lower pressure of steam.

Q. 32.—Will an injector work if all the steam is not condensed by water?

A. An injector will not work if all the steam is not condensed by water.

Q. 33.—If injector will not prime, where would you look for cause? If injector primes well, but breaks when steam is turned on, where is the trouble?

A. If an injector fails to prime, the first place to look is to see whether there is sufficient water in the tank, then look for other causes, and if injector primes well, but breaks when the steam is turned on, water is too hot in tank, and the steam from steam ram does not condense.

Q. 34.—What is generally the cause of failure of the second injector, and what should be done to obviate this failure?

A. The failure of a second injector to work is usually because it has not been worked sufficiently to keep body of injector clear from lime and other obstructions.

Q. 35.—What are the advantages of the combination boiler check and stop valve, and how can one with vertical stem be closed? With horizontal stem?

A. The advantage of the combination boiler check and stop valve are that these can be closed and work done on the injector without the necessity of removing boiler pressure by cooling off. A combination boiler check with a vertical stem should be turned to the left to close, as valve seats on inside toward boiler. A combination boiler check with a horizontal stem turns to right as valve seats outward from boiler.

Q. 36.—What are the principal causes that prevent a locomotive boiler from steaming freely?

A. The principal causes that prevent a boiler from steaming freely are draft appliances not properly adjusted, leaks in steam pipes, flues choked up, valve piston packing blowing, water level not properly maintained, bad firing, and poor coal. Also not sufficient air passing through grates, and openings not large enough in ash pan.

Q. 37.—Give principal cause for waste of fuel from locomotive due to conditions over which the fireman has control.

A. Too much coal on tender which the shaking of the engine causes to fall along the right of way from the top of the tenders or out of gangways; coal not properly broken, furnace door open too long at a time, blower on too strong, heavy firing, and allowing engine to pop; also temperature in firebox not high enough to allow perfect combustion.

Q. 38.—What is a slide valve? How is it balanced, and why? What is a piston valve? How is it balanced?

A. A slide valve is a valve having square corners passing over a flat surface known as a valve seat. Valve has a cavity on under side, and is of sufficient length to cover all steam ports. It is so arranged that while one end of valve is allowing steam to pass into cylinder the under side of valve is allowing steam to pass from cylinder to atmosphere. The slide valve is balanced by means of strips held by springs, and the object is to relieve pressure from top of slide valve. A piston valve is a spool shaped valve having packing rings at each end and is of cylindrical form and operated in a cylindrical chest of equal diameter. It is balanced by allowing steam to pass around stem connecting both ends.

Q. 39.—What is meant by outside and inside admission valves?

A. An outside admission valve is one that allows steam to pass into cylinder from outside of alve, and inside admission valve is one that admits steam from inside of valve. Therefore, all piston valves are usually inside admission valves.

Q. 40.—What are the principal parts of the Stephenson valve gear, having indirect motion and how do they act?

A. The principal parts of the Stephenson valve gear having indirect motion are the eccentrics, eccentric blades, links, link blocks, rocker arms, and valve stems. In an indirect Stephenson valve gear, the rocker arms point in opposite directions.

Q. 41.—How does direct Stephenson valve gear differ from the indirect?

A. The Stephenson valve gear having direct motion has the rocker arms pointing in the same direction either up or down, and sometimes a transmission bar is used which imparts the motion direct from the link to the valve stem.

Q. 42.—What are the principal parts of the Walschaert valve gear, and how do they act?

A. The principal part of a Walschaert valve gear are the eccentric arm, eccentric rod, link, link block, radius rod, union link, crosshead arm, lap and lead lever, and valve stem. Radius rod is connected with lever operated in cab by means of reach rod.

Q. 43.—Is the Walschaert gear direct or indirect?

A. The Walschaert gear is both direct and indirect in its action, according to the position of the block in the link. When the block is below the center of the link, the motion is direct; and it is indirect when block is above center of link.

Q. 44.—In what particulars does the Walschaert gear differ from the Stephenson gear, and what are the advantages of these?

A. The Walschaert gear being placed on outside of frame and wheels makes it more easily inspected. It is also more convenient to repair or disconnect a Walschaert valve gear on this account. The friction also is less because the wearing parts are much lighter than the Stephenson gear.

Q. 45.—How is the lead affected by movement of the reverse lever with the two valve gears?

A. In the Walschaert gear, the lead remains the same when reverse lever is moved, but in the Stephenson gear, the lead is increased as reverse lever is brought near center of quadrant.

Q. 46.—What are the positions of the eccentrics relative to the main crank pin on different valve gears?

A. The positions of the eccentrics relative to the crank pin on different gears are as follows:

With an indirect outside admission, and a direct inside admission, the eccentric follows the pin a quarter of a turn or 90 degrees, but with an indirect inside admission, and a direct outside admission, the eccentrics lead the pin a quarter of a turn or 90 degrees.

Q. 47.—In reversing how do the two valve gears differ as to the movement of the link and link block?

A. When reversing the Stephenson valve gear, the links are raised and lowered and the block remains stationary, but with the Walschaert gear, in reversing, the link remains stationary and the block is raised or lowered.

Q. 48.—What is the difference in a valve and piston blow?

A. The difference in the valve or piston blow is as follows: A valve blow is more continuous and has a different sound from the piston or cylinder packing. Cylinder packing blows the hardest at the beginning and middle of the stroke, and gradually decreases as the stroke is completed.

Q. 49.—How can a broken piston valve packing ring usually be detected?

A. A broken piston valve can usually be detected by the engine going lame.

Q. 50.—What would be the result if an exhaust ring on an inside admission valve was broken? If a steam ring was broken?

A. If an exhaust ring on admission valve becomes broken, the engine would apparently go lame, and the exhaust would seem longer than normal. If the steam ring was broken, the engine would go seriously lame and blow in certain position.

Q. 51.—How would you determine blow in cylinder packing?

A. A blow in cylinder packing can be determined as follows:

Place engine on upper quarter on side to be tested; place reverse lever in center; apply the brakes; open both cylinder cocks; and then open throttle. If steam comes from either cylinder cock, it indicates that valve is leaking. However, if on trial, steam valve is found to be tight, throw reverse lever in forward motion. Steam is now in rear of cylinder, pushing piston ahead. Should steam come out of front cylinder cock, it indicates that back rings of piston are leaking. If, on trial, piston rings in back end are found tight, then throw reverse lever in full back motion and open throttle. If steam appears at back cylinder cock, front piston rings are leaking. Both sides can be tested in same manner.

Q. 52.—Explain the operation of the sight-feed lubricator.

A. The operation of the sight-feed lubricator is as follows: Steam is turned on from the turret and allowed to pass into the condensing chamber on top of the lubricator. After it has condensed to water, it is allowed to flow into chamber holding oil. The water being heavier than the oil, forces the oil on top of water and it passes down through a pipe leading to feed valves. By regulating valves at this point, oil is allowed to pass up in small drops through water glass to pipes leading to cylinders. Water in the sight-feed glass is provided for through the equalizing tubes, which pass from condensing chamber to where oil starts to go to cylinders. These equalizing tubes, in addition to supplying water for sight-feed glass, are used to equalize steam coming from steam chests when throttle is open. Water is constantly accumulating in water glass and flowing through pipes towards the cylinder. As the oil is allowed to pass by regulating valves in drops up through the sight-feed glass, it rides through into the pipes leading to cylinders on top of water, flowing from top of sight-feed glass.

Q. 53.—What is the purpose of the choke plugs and where are they located?

A. Choke plugs are used to help equalize the steam in lubricator and steam chests. Sometimes they are located where oil pipes connect at lubricator, and at other times they are placed in pipes just above steam chest.

Q. 54.—How should the choke plugs be cleaned?

A. Any obstruction in choke plugs may be blown out by removing feed valve on bonnet, closing all connections to the lubricator. If throttle is then opened, steam from the steam chest will blow back through choke plugs, cleaning out any obstruction, or an engine may be reversed while in motion, which will cause a back pressure to come up to lubricator, blowing out choke plugs. In cases where this cannot be done, oil pipe will have to be disconnected and choke plugs removed.

Q. 55.—If the lubricator feeds faster when the throttle is closed than open, where is the trouble?

A. When lubricator feeds faster when throttle is closed than open, it indicates that the choke plugs are loose or the holes in choke plug too large.

Q. 56.—If sight-feeds get stopped up, how should they be cleaned?

A. When sight-feeds get stopped up, they can be cleaned as follows:

Close all valves to other feeds, open drain cock and regulating valve, and the pressure from the equalizing tube will force obstruction out of the feed nozzle and up into the body of the injector; then open the regulating valve until the feed glass fills with water; then open water valve and start all feeds.

Q. 57.—Can you explain the use of the equalizing pipe?

A. Equalizing tubes are placed in a lubricator for the purpose of equalizing pressure coming into lubricator from pipes leading to steam chest when trottle is open.

Q. 58.—What will be the effect if an equalizing pipe were broken off or became very loose?

A. If an equalizing tube be broken or becomes very loose, the lubricator will fail entirely, as there will be nothing to stop the back pressure from steam chests.

Q. 59.—What indicates that the equalizing tubes are stopped up?

A. If the equalizing tubes are partially stopped, we have the same indication as when we have enlarged choke plugs, but if equalizing tube is stopped entirely, lubricator will fail.

Q. 60.—What would happen if the pressure in the oil pipes became less than that in the steam chests?

A. If the pressure in the oil pipes becomes less than that in the steam chest a water seal will form, preventing oil from passing to steam chest from lubricator.

Q. 61.—When a water seal forms in the oil pipes and the valves become dry, how can it be overcome?

A. To remove water seal from an oil pipe, shut off throttle slightly or let reverse lever go down in the corner for a few minutes, which will relieve the back pressure in oil pipe and allow the oil to resume its course towards steam chest.

Q. 62.—Give the principal causes of the formation of a water seal in the oil pipes.

A. The principal cause of the formation of a water seal would be the uneven pressure between the cylinders and the lubricator, caused by too small an opening in steam ram connecting boiler with lubricator. Sometimes an engine will form a water seal by running with a short cut-off and throttle wide open, which increases the back pressure from steam chest to lubricator.

Q. 63.—What is the trouble with the lubricator when it feeds very small drops, and what can you do to increase the size of same?

A. The cause for a lubricator feeding small drops is usually a dirty water glass and water being too heavy. In such cases water glass should be blown out and allowed to fill with fresh, clean water.

Q. 64.—Why is it essential to watch the feeding of the lubricator when running on the road, although the feeds have been set before leaving terminal?

A. When running on the road, lubricator is subjected to currents of air and is apt to become cooled which will affect the drop of oil passing through sight-feed glass, and close watch of lubricator should be kept at all times.

Q. 65.—What is a flange oiler, and what is its purpose?

A. Flange oiler is a lubricator operated from cab, which will throw oil against flanges of wheels when passing around curves to decrease friction and prevent wearing of flanges.

Q. 66.—What is saturated steam?

A. Saturated steam is steam confined in the same vessel with the water from which it is being produced.

Q. 67.—Describe in a general way a superheating appliance as applied to a locomotive, and how it superheats the steam.

A. A superheating device on an engine is an apparatus for re-heating the steam after it has left the boiler and before it is used in cylinders. This re-heating of the steam is usually done by allowing it to pass through tubes placed inside of boiler flues in such a manner that it is subjected to the heated gases on their way from firebox to stack. It is thus possible at times to heat steam up to 600 degrees Fahrenheit after it left the boiler at a temperature of 387 degrees.

This retards the condensation of the steam before it is used in the cylinders.

Q. 68.—Why is a locomotive using superheated steam more economical than one using saturated steam?

A. Superheated steam is more economical than saturated steam because it retains its temperature longer, thus being a means of saving coal and water.

Q. 69.—Should the lubrication of engines using superheated steam receive closer attention than saturated steam engines, and why?

A. The lubrication of engines using superheated steam should be watched closer than engines using saturated steam because superheated steam is so dry that it absorbs the moisture in oil more quickly, allowing the oil to become hard and unfit for use.

Q. 70.—What particular attention should be given the piston rod packing on a superheated engine?

A. When engines are using superheated steam, the piston and valve stem packing and the swabs and oil cups connected with same should be watched very closely in order to prevent unusual wear on valve stems, pistons, etc.

Q. 71.—How should you clean out the sand traps in an air sander where the traps are located outside of sand box? Where located inside of box?

A. Where the traps on an air sander are located outside of the sand box, they can be cleaned by removing the plug in the bottom of the trap, but where they are located inside of the box, turn on air, hold hand on discharge end of sand pipe, and the jet of air will blow back into the sand box and blow any obstruction that might be there with it.

Q. 72.—Should a hammer be used to pound the side of any sand pipe or sand trap in order to clear them of obstruction?

A. A hammer should never be used to pound the side of sand pipe, as it is apt to batter and crack pipe.

Q. 73.—Why should the rails be sanded in starting the train, and why is it important that the sand falls on both rails?

A. Rails should be sanded in starting engine to prevent slipping of wheels and both rails should be sanded in order to prevent one wheel slipping and putting unusual strain on journal when the other one holds the rail.

Q. 74.—If the steam heat gauge showed the required pressure and cars were not being heated properly, how should one proceed to locate the trouble?

A. If steam gauge shows required pressure, and the cars are not being properly heated, a stoppage should be looked for in steam heat pipe or hose. If these are free from obstructions, look for steam valve in cars being closed.

Q. 75.—What should be done, after coupling to train, if you could not get the steam to go through Mason, Leslie, Gold or Ward steam regulator?

A. If a Mason steam heat regulating valve, the bottom cap can be removed and a washer inserted, or any other substance below the piston, which will force the valve off the seat and give a clear opening for the steam. In cases of Gold, Ward or Leslie valves, the caps can be removed and main valves taken out and cap replaced. In such cases, steam will have to be regulated at the throttle.

Q. 76.—While running under steam, and there is a failure of a part of the locomotive which does not seem to prevent running at full speed, how would you proceed?

A. While running under steam, and there is a failure on the part of the locomotive, which does not prevent running, would keep on going until engine could be stopped at station between switches so as to clear main track and then cause of failure located.

Q. 77.—What are some of the various causes for pounds?

A. A loose piston rod in head, crosshead loose on piston rod, crosshead loose on account of not being sufficiently lined, pin loose in crosshead, main rod having lost motion in forward end, and in back end, worn driving box, driving box wedges down, pedestal binders loose, broken frame, loose or lost cylinder key, loose crank pins, and water in cylinders will cause pounds.

Q. 78.—What results from loose deck bolts? Loose or lost cylinder keys? How should they be treated?

A. Loose deck bolts will cause a pound and wear the holes out of round. This pound is often the cause of coal dropping out of gangway, and should be reported as soon as possible. A loose cylinder key should be tightened at once, and if lost, something should be substituted in its place. If it is not taken care of at once, cylinders are apt to become loose on frame.

Q. 79.—Why is it necessary that pedestal braces or binders be kept tight and to maintain a good fit?

A. Pedestal braces or binders should be kept tight to prevent breaking the paws of frame.

Q. 80.—How can a pound in driving boxes or rod brasses be located, and how should these pounds be treated?

A. Place the engine on upper right quarter, block the wheels, give the engine a little steam, and work reverse lever backward and forward, and by standing on the ground near the engine while this is being done, the pound can be quite readily located. After right side has been inspected, do same thing with left side.

Q. 81.—What is the first thing to do when a driving box begins to heat, and what are the remedies?

A. When a driving box commences to heat, the first thing to be done is to pull down wedge so it will not bind, and see that lubrication is taken care of. If, on investigation, it is found that the driving box cellar has been lost, one should be substituted made of tin, and if this cannot be done, tie a piece of waste in such a manner that it will not be lost off and keep this saturated with oil. If it is found that journal is cut, the weight should be taken off as much as possible from journal until terminal point is reached.

Q. 82.—What would you do in case of a broken or very badly cut driving box brass, if the application of either oil or water would not keep the journal running cool?

A. In case of a very badly cut or broken driving box, the weight should be taken off of the box by running wheel on a block or wedge, and placing a piece of hard wood or iron between the top of the spring saddle and the frame. In case an equalizer was used over the driving box instead of spring saddle, place blocking under ends of equalizer.

Q. 83.—What causes driving boxes to break?

A. Driving boxes are broken sometimes by allowing wedges to become too loose, and the box becoming very hot.

Q. 84.—What are the principal causes of side rods breaking and to what extent can this be avoided?

A. Principal causes of side rods breaking are usually that the pins have been allowed to work out or the wedges are down too low, which throws the strains which should be carried by main frame on the side rods. Anything also that allows the journal to roll back and forth will have the same effect as a loose wedge.

To avoid breaking of side rods, knuckle pin nuts should be kept tight, wedges set up properly, driving box brasses reported before they become too badly worn.

Q. 85.—How should the work of setting up the wedge be done?

A. To set up the wedges on an engine, place the engine on the upper forward eighth on the right hand side. This will bring engine on upper back eighth on left hand side. Block wheels and give engine steam, which will have the effect of drawing the wedges up on all the wheels, and allowing them to be set up all around without further movement of engine.

Q. 86.—How should an engine be placed for the purpose of keying rod brasses and why necessary to keep keyed brass to brass?

A. For the keying of rod brasses, engine should be placed on the dead center so that side rods will be of the proper length. Main rod brasses should be keyed at a point where engine has just passed dead center and before valve has commenced to open for the admittance of steam into cylinder. This is the large part of the pin, and brasses keyed at this point will not bind.

Q. 87.—What is the danger when water is carried from the boiler into cylinders?

A. When water is carried into the cylinders from the boiler in too large quantities, it will break cylinder heads and has been known to break bridges in slide valve seats.

Q. 88.—What usually causes steam chests to crack or break, and what can be done to prevent it?

A. Reversing an engine when running fast will cause an abnormal pressure in steam chest and will sometimes cause them to crack or break. The pressure on the steam chest can be relieved at such times by opening the throttle, allowing boiler pressure to go into cylinders, which will equalize that pressure with the boiler, and nothing greater than boiler pressure can be confined in there at that time.

Q. 89.—If the reverse lever, reach rod, reverse shaft or arms, link hanger or saddle be disabled, how would you proceed with Stephenson valve gear? How with the Walschaert gear?

A. In the case of a Stephenson valve gear, the links will have to be blocked in running position, but with a Walschaert gear, the block is placed in running position by means of blocks placed above and below the block attached to radius rod. In case it becomes necessary to reverse an engine, blocking in the links would have to be reversed.

Q. 90.—Can the locomotive be reversed under these circumstances, and how?

A. Yes; a locomotive can be reversed by reversing blocking.

Q. 91.—If a link block pin breaks or gets fast in the block, what would you do on a Stephenson gear? What on Walschaert gear?

A. If a link block pin breaks or gets fast in the block of a Stephenson gear, would endeavor to take out broken pin and substitute something in its place. If this cannot be done, would cover ports and remove disabled part. With the Walschaert gear, take down the eccentric rod, cover the ports, disconnect the radius rod, and fasten it to the running board. In all cases, the valve must be securely fastened to cover ports.

Q. 92.—If one of the bolts connecting the two parts of a built-up link on Stephenson gear breaks or is lost, how would you proceed?

A. In a built-up Stephenson link, the bolts at the top and bottom are supposed to be interchangeable. If the top should break, would remove the bottom one and place it on top, fasten bottom of link with wire, and proceed.

Q. 93.—How would you locate a broken slide valve yoke or stem inside the steam chest and put engine in safe running order?

A. Place engine on quarter and open cylinder cocks. Give engine small amount of steam, moving the lever to extreme forward and back motion. If valve yoke, the valve will be left in front end of steam chest. To place the engine in safe running condition, block valve to cover the ports. Provide for lubrication and proceed.

Q. 94.—If a front cylinder head or piston is broken, how would you proceed?

A. Disconnect valve stem, secure valve to cover the ports, provide for lubrication and proceed.

Q. 95.—What can be done if the intermediate side rods were broken on a Consolidation engine having the eccentrics on the axle ahead of main wheel?

A. In this case, an engine would be disabled and would have to be towed in.

Q. 96.—If a piston rod, back cylinder head, guides, main cross head, main rod or crank pin is disabled, what should be done?

A. Take down main rod, remove all broken parts, cover ports, and proceed on one side.

Q. 97.—If a side rod is bent or broken, what should be done.

A. If a side rod is bent or broken, take down both side rods. It is well to take the good one down first, which will relieve the strain on the other side and make it easier to take off the bent one. Proceed under steam on both sides.

Q. 98.—If an eccentric or strap, or eccentric rod on the Stephenson gear becomes disabled, what should be done? How would you lubricate the cylinder?

A. Take down all broken parts, secure valves to cover ports, provide for lubrication, and proceed; lubricate cylinder, which can be done by loosening some of the test plugs or loosening the cylinder head by slacking off on the bolts.

Q. 99.—If an eccentric crank or eccentric rod becomes disabled on the Walschaert gear, what should be done?

A. Engine will have to be placed so that valve covers ports, as she has lost control of her valve motion on the side disabled. Provide for lubrication and proceed with one side.

Q. 100.—If either arm of a rocker shaft on Stephenson gear breaks, what should be done?

A. If either arm is broken, engine has lost control of her valve stem on that side. Valve will have to be secured to cover ports, lubrication provided for, and proceed with one side.

Q. 101.—If the crosshead arm, combination lever, or connection on Walschaert gear becomes disabled, what should be done?

A. Fasten the combination lever so as to clear the crosshead while in motion. Take down eccentric rod, clamp valve to cover ports, and proceed.

Q. 102.—If the radius rod on Walschaert gear is disabled, what should be done?

A. If the radius rod is broken in front of the link, valve motion on that side of the engine is thrown out of commission, and valve will have to be clamped to cover port, provide for lubrication, and run engine with one side. But if radius rod is broken back of the link, the radius rod can be blocked in desired running position. Proceed with both sides.

Q. 103.—How are the metallic packing rings on valve stems and piston rods usually held in place, and what provision is made for the movement of the rods?

A. Metallic packing rings are held in place on valve stems and piston rods by means of a coil spring. A ball joint and ground joint permit the packing to rise and fall with the rod or valve.

Q. 104.—What should be done should the grates be burned out, or broken, while on the road?

A. Grates burned out on the road can be replaced by short pieces of iron, or in some cases where these cannot be procured, brake wheels can be procured from the cars and substituted, but in such cases, the crew should be notified that wheels are gone. Wheels should not be taken only in extreme cases.

Q. 105.—Suppose that immediately after closing the throttle the water disappeared from the water gauge and cocks, what should be done?

A. The reverse lever should be brought close to the center and throttle opened wide, then put on injectors until water shows in the glass when throttle is closed.

Q. 106.—What should be done in case a throttle stem became disconnected while the throttle valve is closed, and if it becomes disconnected while throttle valve is open?

A. If throttle becomes disconnected while closed, nothing can be done but call for relief engine, but if it becomes disconnected while throttle is open, steam pressure on locomotive can be reduced, and engine controlled by reverse lever and air brake.

Q. 107.—What should be considered a bad tender or engine truck wheel?

A. Any tender or engine truck wheel which has a sharp flange, being less than 1" thick at base, the wheel on which flange is worn to a vertical surface of 1", a wheel having a seam or crack around its circumference at the base of the flange, a wheel being worn through the chill of the tread 3/16" deep, flat spots in a wheel over 2½" long, a chipped or broken flange.

Q. 108.—How should an engine be blocked for broken engine truck spring or equalizer? For broken tender truck springs?

A. Procure a piece of iron the right length, or a square timber and block between truck boxes and engine frame. Then run slow and careful. A broken truck spring should be blocked in the same manner.

Q. 109.—What should be done if a driving spring hanger or equalizer should break?

A. Either run engine up on a block or jack it up, and take out disabled parts. Then block between frame and driving box. If some of the springs and equalizers are all right, block ends of equalizers where springs are taken out.

Q. 110.—If the throttle were closed and steam came from cylinder cocks, is it possible to distinguish causes, and how would you determine various causes?

A. If throttle is leaking, dry steam will come from cylinder cocks. If dry pipe is leaking, both steam and water will come from cylinder cocks.

Q. 111.—What should be done if upper rail of frame is broken between main driver and cylinder; if lower rail; if back of main driver?

A. Should the upper rail of frame be broken between main driver and cylinder, engine should be run light to terminal. and must not be double-headed. If top rail be broken back of main driver, tonnage should be reduced to a point of safety and engine proceed. If lower rail of the frame should be broken, it is usually not necessary to give up train, but all rough usage of engine should be avoided.

Q. 112.—What should be done if a driving tire should break?

A. Either run wheel upon a block, or jack up engine far enough to take out driving box cellar, substituting a block of hard wood and inserting block under end of equalizers. If tire should break on Consolidation engine equipped with middle driver, care should be exercised to chain the back or front of engine so it will crowd good tire close to rail. Driver brake should be cut out.

Q. 113.—How can it be known whether the wedges are set up too tight and the driving box sticks, and in what manner can they be pulled down?

A. This can easily be told because the engine rides hard. Run the engine over a nut or block of wood, which will start wedge down.

Q. 114.—What constitutes abuse of an engine?

A. Failing to inspect engine either before or after a trip; not taking proper care of wedges and brasses; allowing nuts and bolts to become loose and lost; not oiling properly; failing to open cylinder cocks in order to free them from condensed steam; filling boiler too full of water; working engine in corner when a shorter cut off will do as well. Reversing engine with throttle open and cylinder cocks closed. Allowing engine to slip, and sand to fall on one rail only, and not closing throttle when engine is slipping before allowing sand to fall on rails.

Q. 115.—In reporting work on an engine, is it sufficient to do it in a general way, such as saying: "Injector won't work;" "Lubricator won't work;" "Pump won't work;" "Engine blows;" etc.?

A. No. An engineer should be capable of locating all defects on an engine, and report in full, accordingly, when he makes out his work report at end of trip.

Q. 116.—If you were required to take a light engine over the road that has undergone heavy repairs, what would be your duty before starting, and how would you care for the engine while on the road?

A. Would make a careful examination to see that all repairs have been properly made on engine, and that all bearings are getting proper lubrication. The driving box wedges and rod keys are not too tight; all nuts, bolts and all other parts in proper condition and provide a supply of oil to use, if necessary.

Q. 117.—What necessary qualifications should an engineer possess to be successful?

A. He must have a perfect understanding of the operation of all parts of a locomotive, in order that he can do the most work for the Company, by using the smallest amount of supplies possible. He must have a correct understanding of all operating rules of the Company that employs him.

BAKER VALVE GEAR

Q. 118.—Wherein does the Baker valve gear differ from others?

A. The Baker gear dispenses with the link, and the motion is obtained from the eccentric crank and crosshead.

Q. 119.—Name the parts of the Baker valve gear.

A. Eccentric crank, eccentric rod, radius bar, reverse yoke, bell crank, bell crank arm, valve stem, combination lever, gear connection rod, union link, crosshead arm and reach rod.

Q. 120.—How would one disconnect for a broken eccentric rod or crank.

A. Holes are provided in the frame for blocking bell crank, and by placing reverse lever in center of quadrant will place crank in position to block. Take down eccentric rod and take out pin of short reach rod, throwing reverse yoke over against frame.

Q. 121.—If lower part of gear connection rod breaks, what should be done?

A. Block in same manner as broken eccentric rod or crank.

Q. 122.—If upper part of gear connection rod breaks, what should be done?

A. If broken close to middle pin, block in same manner as for broken eccentric rod, tying lower end of gear connection rod to keep from swinging, but if break is close to the top and below the jaw, block bell crank and wire connection rod fast to radius bars.

Q. 123.—In case a radius bar should be disabled, what can be done?

A. Block same as for broken eccentric rod.

Q. 124.—What should be done for a broken bell crank vertical arm?

A. Union link, combination lever and valve rod should be taken down, then valve can be blocked over port by screws provided for that purpose.

Q. 125.—How should the gear be disconnected for disabled horizontal arm bell crank?

A. Block same as for broken eccentric rod.

Q. 126.—How can the engine be brought in with a broken crosshead arm?

A. Put reverse lever in middle of quadrant and plumb combination lever and fasten it in that position by tying union link to guide yoke.

Q. 127.—What should be done in case of a broken union link?

A. Block same as for broken crosshead arm.

Q. 128.—What should be done for a broken combination lever?

A. Block ports, taking down combination lever and valve rod.

Q. 129.—How would you disconnect for a broken valve rod?

A. Block valve to cover ports and take down broken parts.

Q. 130.—What should be done if the reverse yoke becomes disabled?

A. Place blocks of wood in front and back of yoke and take down reach rod. If broken below the ears, act the same as for broken eccentric rod.

Q. 131.—What must be done if either reach rod breaks?

A. The yoke should be blocked as in preceding cases.

Q. 132.—How should the engine be blocked for broken reverse arms?

A. Reach rod should be taken down and yoke blocked on disabled side.

OIL BURNING LOCOMOTIVES

Q. 133.—What is the fireman's first duty on taking charge of engine?

A. Fireman must see that oil is properly heated to flow freely to burner and that heater is properly adjusted.

Q. 134.—How should the atomizer be started?

A. The steam in atomizing pipe should be turned on slightly, and then oil allowed to flow, and just enough quantity to take care of required fire.

Q. 135.—How should the pilot light be started?

A. An oil saturated and lighted piece of waste should be thrown into firebox. Then atomizer turned on slowly and oil next, allowing spray to play against lighted waste and ignite.

Q. 136.—Why should the direct heater not be used more than absolutely necessary?

A. Too much heat should not be used, because oil would become too high in temperature, and not feed to burner in regular flow, on account of gas forming in pipe.

FEDERAL REGULATIONS FOR INSPECTION OF LOCOMOTIVE BOILERS

Q. 137.—What is the purpose of the Federal Rules and Regulations for inspection of locomotive boilers?

A. To make it necessary that all railroads inspect, maintain and operate locomotive boilers in the same manner.

Q. 138.—What is the purpose of the annual and monthly Interstate inspection cards placed in the cab of the locomotive?

A. To show the enginemen and Federal Inspectors that boilers have been properly inspected, operated and maintained.

FEDERAL REGULATIONS FOR SAFETY APPLIANCES

Q. 139.—What constitutes a safety appliance, as applied to a locomotive?

A. Any parts of a locomotive especially constructed and applied for the safety of all employes whose duties require them to work on or about the engine.

Q. 140.—Name some of the safety appliances found on a locomotive.

A. Hand holds, hand rails, couplers, coupler operating levers, steps, ladders and air-brake.

Q. 141.—In what condition should safety appliances be maintained?

A. In a perfectly safe condition.

Q. 142.—What should be done in event of any of the safety appliances being damaged while engine is in service so as to render it unsafe?

A. The person in authority or responsible, should be inforced at once, and engine relieved from service until repairs are made.

Q. 143.—What effort should be made on the part of the engineer to prevent persons using a safety appliance which he knows is damaged and unsafe?

A. He should order all employes to avoid using disabled safety appliances.

Q. 144.—What is the duty of the engineer in event of his discovering a safety appliance which is in an unsafe condition when taking an engine from roundhouse territory?

A. The attention of his Foreman should be called to the unsafe condition of appliances at once, and all necessary repairs made before engine is allowed to go into service.

THIRD YEAR'S EXAMINATION QUESTIONS ON COMPOUND LOCOMOTIVES

Q. 1.—Wherein do compound engines differ from ordinary engines, and what is the principal advantage claimed for the compound engine?

A. A simple engine uses steam once and exhausts to atmosphere. A compound engine uses steam at least two times before exhausting to atmosphere. The principal advantage claimed is that a compound engine makes use of power that is otherwise thrown away, and saves just that much coal and water.

Q. 2.—Why is one cylinder on a compound locomotive called a high pressure cylinder, and the other one the low pressure cylinder?

A. Because the small cylinder receives its steam direct from the boiler, at boiler pressure, while the large cylinder receives its steam after it has been used and partially expanded in the smaller cylinder, therefore, the small one is called the high, and the large one the low pressure cylinders.

Q. 3.—Is it necessary to know that the oil dash pot contains sufficient oil, and why?

A. The oil dash pot should always contain enough oil to prevent the intercepting valve from slamming, when it is changing position.

Q. 4.—Explain how a Schenectady two-cylinder compound locomotive may be operated as a simple engine.

A. A Schenectady cross-compound has what is known as an intercepting valve. This has a part known as a separate exhaust valve. A pipe leads from the main air reservoir to a cavity in front of the separate exhaust valve, and the air flow is governed by a cock in locomotive cab. When it is desired to work the locomotive simple the cock in cab is turned to simple position, which allows air to flow in front of separate exhaust valve, forcing it open and holding it there. In this position the high pressure cylinder exhausts directly to atmosphere, and so does the low pressure cylinder which is now getting its steam direct from the boiler through a small supply pipe, and reducing valve, which makes the pressure in large cylinder equal that in small cylinder. Locomotive is now said to be working simple.

Q. 5.—When should a Schenectady compound be operated as a simple engine, and why not operate as a simple engine when running fast?

A. When it is necessary to start a heavy train and a long, slow pull is needed. When quick moves are needed, as around yards, turn-tables, coal docks and water plugs. However, locomotive should not be run faster than eight miles an hour, as large cylinder would not be receiving steam fast enough, and pulling strains would be unequal.

Q. 6.—Explain how a two-cylinder compound engine is changed from simple to compound.

A. Move cock in cab to compound position, which will allow air in front of separate exhaust valve to go to atmosphere, and allow a spring to close valve. In this position steam from high pressure cylinder exhausts over to receiver pipe of intercepting valve. As the high pressure cylinder continues its exhausts, a pressure is built up in intercepting valve which finally moves it into compound position and allows exhaust steam from high pressure cylinder to take possession of steam chest on low pressure cylinder and operate it. In this position the low pressure cylinder is shut off from its small supply pipe and reducing valve.

Q. 7.—What moves the intercepting valve in a two-cylinder compound?

A. Exhaust steam from high pressure cylinder moves it into compound position. Steam from small supply pipe and reducing valve moves it into simple position.

Q. 8.—How should a compound locomotive be lubricated, and why feed more oil to the high than the low pressure cylinder?

A. The high pressure cylinder should be fed the most oil, as the steam passing from it to the low side carries oil with it, when working compound. But in simple position, both cylinders should be oiled alike.

Q. 9.—How would you lubricate the valve to low pressure cylinder if oil feed became inoperative on that side?

A. Would feed a larger amount than usual to high pressure side, and also a larger amount to intercepting valve. By going to simple position now and then the oil in intercepting valve would be carried to valve on low pressure side.

Q. 10.—How much water should be carried in a boiler of a compound locomotive? Why?

A. About what would show as half a glass full, or two gauges. If carried higher it is liable to go through throttle to cylinders injuring intercepting valve.

Q. 11.—When drifting, what should be the position of the separate exhaust valve, cylinder and port cocks?

A. All open whenever steam is shut off.

Q. 12.—What will cause two exhausts of air to blow from the three-way cock when engine is being changed to compound?

A. Because the air chamber in front of separate exhaust valve may be dry, and when air is exhausted from it, separate exhaust valve does not close until pressure behind it slams it shut. This will cause the second exhaust.

Q. 13.—What does steam blowing at three-way cock indicate?

A. A leaky separate exhaust valve.

Q. 14.—What can be done if engine will not work compound, when air pressure on the separate exhaust valve is released by the three-way cock?

A. This indicates that separate exhaust valve is stuck open, and a slight tapping with hammer will sometimes cause it to snap shut. If this does not answer, disconnect the air fastenings to separate exhaust valve, take nuts off from middle studs of exhaust valve casing, pull out casting and examine valve.

Q. 15.—If the engine stands with high pressure side on the dead center, and will not move when given steam, where is the trouble and what may be done to start the engine?

A. Engine is in compound position, and intercepting valve is stuck. Open all cylinder and port cocks after closing throttle. Take a bar and push in shaft which passes through and back of oil dash pot. This will move intercepting valve to simple position and live steam can pass to low pressure cylinder.

Q. 16.—Give reason for reply to previous question.

A. If all cocks should be left closed engine would move when finally forced to simple position, and injure some one.

Q. 17.—In the event of a breakdown, how should one disconnect?

A. Disconnect the same as with simple engines, and then operate in simple position.

Q. 18.—What may be done to shut off steam pressure from the steam chest and low pressure cylinder?

A. Open the separate exhaust valve, then pull back on the rod that passes through oil dash pot as far as it will go and clamp in that position.

Q. 19.—Is it important that air be pumped up on a Schenectady two-cylinder locomotive before the engine is moved? Why?

A. Yes; because air is needed to open separate exhaust valve, and engine will not move simple until it is opened.

Q. 20.—How are the blows in a compound located?

A. Same as simple engine, but separate exhaust valve must be open.

Q. 21.—What must be done if high pressure piston of a cross-compound is broken off the rod? If high pressure or low pressure cylinder head is broken off?

A. Cover ports of high pressure cylinder, and use low pressure cylinder in simple position. If high pressure cylinder head off, would do the same thing, but if low pressure head be off, would open separate exhaust, pull intercepting valve back as far as it would go by means of rod through dash pot, and clamp it there, opening pop valves and cylinder cocks.

Q. 22.—In the event of separate exhaust valve failing to work when throttle is wide open, what can be done to assist in opening?

A. Throttle should be eased off enough to reduce pressure in receiving pipe, so air in front of separate exhaust valve can force it open.

Q. 23.—If a transmission bar on a cross-compound be broken what would you do? Right side? Left side?

A. On right side would take down broken parts, open separate exhaust, pull intercepting valve back as far as possible by means of dash pot rod, clamp it fast, provide for lubrication and proceed. On left side, would take down broken parts, block valve to cover ports, provide for lubrication, open separate exhaust valve and proceed with low side in simple position.

Q. 24.—In the event of a cross-compound beginning to jerk badly and popping off at the pops on end of low pressure cylinder, where would you look for the trouble?

A. Live steam is getting into receiver pipe through leaky high pressure valve or piston packing.

Q. 25.—If out on a trip and you found piston valve rings of a cross-compound were broken, what would you do?

A. Pressure should be reduced to a point where train could still be moved and then proceed.

Q. 26.—If piston valve be broken on cross-compound so it becomes necessary to remove same, what should be done?

A. Reduce pressure about one-half and proceed, assuming that boiler usually carries 200 pounds.

Q. 27.—Wherein does the Mallet compound differ from other types of compound engines?

A. It consists of a locomotive having two high and two low pressure cylinders. The two high pressure cylinders, one on each side, exhaust into a receiver pipe which, when proper pressure is built up, supplies steam to operate low pressure cylinders, one on each side, when working in compound position. All cylinders, however, can be operated in simple position when necessary.

Q. 28.—What advantages are claimed for this particular type of locomotive?

A. Having a better distribution of steam, in proportion to weight on driver, a better tractive power is obtained with a less consumption of fuel and water.

Q. 29.—What particular attention should be given the locomotive before starting?

A. The intercepting valve should be well oiled at start, the articulated connection between the two groups of wheels should be well oiled; ball joints in front of high pressure cylinder and both ball joints of exhaust pipe, and boiler slide buckles should all be oiled. The ball bearings of floating column, and bolts, which connect front and rear frames, should be well oiled.

Q. 30.—What causes a too rapid movement of reverse lever, and what should be done to prevent it?

A. Not sufficient amount of oil in dash pot, which should be always full and closely watched at all times.

THIRD YEAR EXAMINATION QUESTIONS ON AIR BRAKE.

Q. 1.—Explain in a general way the operation of the Westinghouse 9½" or 11" pump.

A. The pump consists of two large cylinders fastened to one frame, one above the other, with a single piston rod running up and down through them and a piston head in each cylinder. The upper cylinder is operated by steam, and the piston, moving up and down, causes the lower piston to do the same. By means of inlet and discharge valves, in lower cylinder, air is drawn in and then by compression forced into what is known as the main reservoir. On top of the steam cylinder is the mechanism that operates the pump. It consists of a valve seat with ports to allow steam to go to bottom of steam cylinder, driving it up, and then to its top, driving it down, when piston is moving up, steam on top of it is exhausted to atmosphere, and when it is going down steam underneath is also going to atmosphere. This valve seat is covered by a hollow valve, which is moved forward and back by a two-headed piston, having one head much larger than the other. This is called the differential piston. The heads of this piston contain rings which make piston heads steam tight as they travel back and forth in their circular cage. On the outside of the smaller head of this differential piston is a chamber which is always open to the atmosphere. And on the outside of the larger head is a chamber that is sometimes open to the atmosphere and sometimes not, according to the position of what is known as the reversing valve. This valve is operated up and down by means of a long rod extending down into the piston rod of the big steam cylinder, whose piston rod is made hollow for that purpose. When the pump is at rest, the piston heads, by gravity, fall to the bottom of cylinders. The steam piston, when going down, pulls the reversing valve with it, and this opens the chamber on the outside of the big differential piston head, to the atmosphere. Now, when steam is turned on pump, it goes in between the heads of the differential piston, and the larger, presenting the most steam surface, moves over dragging the little hollow valve with it. Now steam is free to go to bottom of big piston and drive it up. When it goes up, it pushes the reversing valve up, which closes chamber on outside of big head of differential piston, and allows steam to go into the chamber. The big head now has steam on both sides and is practically balanced. Now the little head of the valve is strongest, drags the hollow valve back and allows steam on top of big cylinder piston driving it down. See Figs. 5 and 6.

Q. 2.—Explain in a general way the operation of the Westinghouse 8½" cross-compound pump.

A. This pump uses its steam two times, and compresses the air two times. The pump head is about the same as on the simple pump, excepting the differential piston. This piston, on compound pumps, instead of allowing the first cylinder to exhaust its steam, after using, to the atmosphere, has ports which allow steam to go to top and bottom of low pressure cylinder, and then to atmosphere. The air is compressed in one cylinder, discharged into other cylinders, compressed again, and then forced into main reservoir. See Figs. 7 and 8.

Q. 3.—Explain in a general way the operation of the New York No. 5 Duplex pump.

A. It consists of two steam cylinders operated simple, but compounds the air. Each cylinder has a reversing valve underneath it which controls the other cylinder. When the pump is at rest gravity brings all pistons down to lowest points in cylinders. Now if steam is turned on to pump the right hand cylinder piston moves up, taking the reversing valve with it. The left hand cylinder piston is now free to move up, taking its reversing valve with it. When it reaches the top, then the right hand cylinder piston starts down. As soon as it gets down then the other comes down. See Figs. 9, 10, 11, 12.

Q. 4.—Explain how an air pump should be started, at what speed it should be run on the road, what lubricant used, and how should air cylinders be lubricated?

A. Open all drain cocks and start slowly, gradually increasing speed of pump when it is free of condensation, and operate just fast enough to supply required air. Oil cups are provided to air cylinders, and good valve oil should be used through them. Steam cylinders should use valve oil fed by lubricator in engine cab.

Q. 5.—If the pump runs hot while on the road, how should one proceed to cool it?

A. Slow up speed of pump and oil with valve oil through oil cups.

Q. 6.—Give some of the common causes for the pump running hot.

A. Running pump too fast. Air compressors not properly lubricated. Valves leaking or stuck shut. Pipes or passages stopped up. Air cylinder packing rings loose.

Q. 7.—State the common causes for a pump stopping.

A. A governor out of order; air piston nuts becoming loose; lack of lubrication in steam head or cylinder, and broken reversing valve stem or plate.

Q. 8.—If a pump makes an uneven stroke, what defect does it indicate?

A. Air valves on air cylinder out of order.

PUMP GOVERNOR

Q. 9.—Explain how the governor works.

A. A governor has a tension spring, resting on a diaphragm, which can be set for any desired pressure. The chamber under the diaphragm is connected to main reservoir. When pressure in main reservoir becomes greater than tension of regulating spring, the diaphragm will raise, allowing air to pass under pin valve, which has also raised, and flow down on top of governor piston, forcing it down, which in turn shuts off steam going to pump, causing it to stop. As soon as pressure in main reservoir becomes weaker than tension of regulating spring, the spring will push the diaphragm down seating the pin valve and stop the flow of main reservoir air on top of governor piston, allowing it and steam valve to raise, permitting pump to resume work. See Fig. 3.

Q. 10.—Why is it necessary that the relief port in the governor be kept open?

A. In order that imprisoned air can escape and piston work promptly. See Fig. 3, letter C.

Q. 11.—If the pin valve in the governor leaks, what effect will it have on the pump?

A. The pump will have a slow movement. See Fig. 3, No. 47.

Q. 12.—How can you tell if the pin valve leaks?

A. A continuous blow will be heard from relief port of governor.

Q. 13.—Why are freight trains equipped with a Duplex governor?

A. When brake valve is on lap it allows a high main reservoir pressure and makes sure a quick release of train brakes. See Fig. 4, BV.

Q. 14.—In what position should the brake valve handle be placed when adjusting governor?

A. For the low pressure governor, place in running position. For high pressure governor place handle in lap position. Fig. 1.

ENGINEER'S BRAKE VALVES

Q. 15.—Name the different positions of the Westinghouse G-6 and H-6, and New York "L" brake valve.

A. For the G-6 valve. Full release, lap, service, and emergency. For the H-6 valve. Full release, running, holding, lap, service and emergency. For the New York "L" valve, same as Westinghouse H-6. See Fig. 1 for the H-6 Valve.

Q. 16.—When making a service reduction with the New York B-3 brake valve, if the valve fails to lap, where would you look for the trouble and what must be done?

A. Either a leak in the supplementary reservoir, its connections, or the equalizing piston would cause the failure to lap. It can sometimes be overcome by moving brake handle slowly to lap position.

Q. 17.—In what position of the brake valve is there a direct communication between main reservoir and brake pipe?

A. Always in full release position.

Q. 18.—Are there any other positions on the brake valves in which air may pass from the main reservoir to the brake pipe?

A. Yes. With the G-6 in running position. With the H-6 and New York "L" in both running and holding. But in all such positions the air passes through a feed valve before reaching brake pipe. See Fig. 13 for Feed valve.

Q. 19.—When making a service application, does one draw air direct from brake pipe?

A. With the exception of New York B-3 valve, when making service application, air is drawn from the equalizing reservoir.

Q. 20.—What defects will cause the black hand on the air gauge to go up and equalize with the red?

A. This indicates main reservoir pressure in equalizing chamber, and may be caused by leaky feed valve or its gasket, a lower body gasket, or rotary valve.

Q. 21.—How can one tell which defect caused black hand to equalize with the red?

A. Bring brake pipe pressure below 70 pounds and close cutout cock. If black hand remains stationary and there is no blow at service exhaust, the trouble would be caused by feed valve or feed valve case gasket. If there is a slight blow at exhaust, and black hand rises, it is rotary valve leaking. If black hand rises and there is no flow at service exhaust port, then the lower body gasket is leaking.

Q. 22.—What is the purpose of the equalizing reservoir?

A. To make a larger amount of air in equalizing chamber over equalizing piston.

Q. 23.—What effect would a leak from equalizing reservoir or its connections have?

A. With brake valve on lap equalizing piston might rise and cause brakes to apply.

Q. 24.—If the pipe connecting the brake valve and equalizing reservoir should break, what should be done?

A. Carry brake valve in running position and plug broken pipe and its exhaust. Then use emergency position of brake valve carefully to make service stops.

Q. 25.—When equalizing piston fails to seat, how can you tell if it is a leakage of equalizing reservoir pressure or dirt on the seat of the valve?

A. If there is dirt on the seat there will be a continuous leak. If equalizing reservoir is leaking it will only show when brake valve is in lap position.

Q. 26.—If there is a continuous blow at the brake pipe exhaust port, what would you do to stop it?

A. Cut out cock below brake valve should be closed, and a service reduction of 40 or 50 pounds made. Then by placing valve in full release and allowing main reservoir air to flow into brake pipe, the equalizing piston will raise and dirt be blown off valve seat.

Q. 27.—What will be the effect if the handle of brake valve is left in full release position too long, and then moved to running position?

A. The brake pipe and auxiliary reservoirs would be charged above feed valve pressure, and brakes would apply.

Q. 28.—What is the purpose of the holding position of the automatic brake valve?

A. To hold brakes applied on locomotive and tender, after brakes on train have been released, and making it possible to restore brake pipe pressure, and still have use of brakes on engine and tender. See Fig. 1.

Q. 29.—What is the purpose of the independent brake valve, used with the E. T., and the straight air brake valve, used with the L. T., and what is the highest brake cylinder pressure developed by its use? How is this pressure regulated? See Fig. 2, for Independent Brake Valve.

A. They are used to apply and release locomotive and tender brakes independent of train brakes, and the maximum pressure used is 40 pounds. This pressure is governed by a reducing valve which also regulates whistle signal line, excepting the L T equipment which has a separate valve for that purpose.

Q. 30.—What should be done to release the brakes, when they do not release with the handle of the straight air brake valve in release position?

A. For a short period the automatic brake valve should be placed in release position and then back to running.

Q. 31.—If the straight air reducing valve leaks, what will be the result?

A. Wheels would slide, if brake should be applied on account of a too high pressure.

NO. 6 E. T. EQUIPMENT

Q. 32.—What are the functions of the distributing valve?

A. In all applications of either automatic or independent brake valves, air is admitted to or released from all brake cylinders on locomotive and tender, by means of the distributing valve. It also automatically maintains any desired cylinder pressure regardless of leaks or piston travel. See Fig. 23, showing release position of valve.

Q. 33.—Where does the brake cylinder air pressure come from when brakes are applied in service? Emergency?

A. On locomotive and tender, from main reservoir, in service, and in emergency from main reservoir and brake pipe.

Q. 34.—What brake cylinder pressure is developed in service? Emergency?

A. When brake pipe pressure is 70 pounds, 50 pounds in service and 65 pounds in emergency. When brake pipe pressure is 110 pounds, 68 pounds in service, and 93 pounds in emergency.

Q. 35.—How does the safety valve control brake cylinder pressure and to what pressure should it be adjusted?

A. It should be adjusted to 68 pounds. It is connected to application chamber in all positions of equalizing slide valve excepting in lap position, and as application chamber controls brake cylinder pressure, pressure in brake cylinders cannot exceed 68 pounds. See Fig. 23 for safety valve.

Q. 36.—Where would you look for the trouble if the driver truck and tender brake releases with brake valve handle in lap position? Holding or release position?

A. Application chamber or its connections are leaking. A leak in distributing valve release pipe. See Fig. 23 for application chamber and release pipe, which is marked IV.

Q. 37.—What is the effect of a leak in the distributing valve release pipe between the independent and automatic brake valves?

A. An independent brake application would not be affected. But an automatic application with automatic valve in release or holding position would be released. See Fig. 23.

Q. 38.—What should be done if the application chamber pipe breaks?

A. Plug the pipe and you have only lost use of independent brake. Brakes can be applied on engine and tender, with automatic brake, and brakes can be retained on engine and tender after train brakes have been released. See Fig. 23. No. II.

Q. 39.—What should be done if the distributing valve release pipe breaks?

A. The pipe should be plugged in freight or switching service, and automatic and independent applications can be released when independent brake valve is in release position. This is unnecessary in passenger service. See Fig. 23, No. IV.

Q. 40.—What should be done if the brake pipe connection to the distributing valve breaks?

A. Close cut-out pipe if there is one; if not, plug pipe. Use independent brake on locomotive and tender, and automatic on train. See Fig. 23, B P.

Q. 41.—If the engine brake creeps on with the automatic and independent brake valves in running position, how would you release it and what defect does it indicate?

A. Place the automatic brake valve in full release and then back to running. Indicates a defective feed valve.

L. T. EQUIPMENT

Q. 42.—What are the duties of the automatic control valve?

A. It admits to, and discharges from, air to all brake cylinders on locomotive and tender, by means of automatic brake valve, and maintains automatically any desired brake cylinder pressure regardless of piston travel or leaks. See Fig. 24 for automatic control valve in full release position.

Q. 43.—Where would you look for the trouble if the locomotive brakes fail to apply, or leak off after a service application?

A. Spring in straight air brake valve may be weak, allowing handle to remain in automatic release position. But there may be leaks in control reservoir pipe, its connections, or cylinder cap gasket.

Q. 44.—What should be done if the brake cylinder pipe breaks between the double chamber reservoir and the double check valves? See Fig. 24. B CYL.

A. If this should happen while train is in motion, and brakes are applied, move straight air brake handle to the automatic release position to save main reservoir air. After coming to a stop close cock in main reservoir supply pipe. See Fig. 24. B CYL.

Q. 45.—What should be done if the control release pipe breaks?

A. The holding feature is lost, and brakes will have to be held on locomotive and tender by means of straight air brake valve. See Fig. 24.

Q. 46.—What should be done if the brake pipe crossover pipe breaks? If the main reservoir supply pipe breaks?

A. Close cut-out cocks in pipes, and use straight air on locomotive and automatic on train. See Fig. 24.

Q. 47.—What should be done if the control reservoir pipe breaks?

A. If the pipe is plugged locomotive brakes can be applied and released by means of the automatic brake valve. See Fig. 24.

TRAIN AIR SIGNAL

Q. 48.—Explain the operation of the whistle signal reducing valve.

A. This valve is placed on locomotive between main reservoir and whistle signal line. It allows air to feed into signal line until a pressure of 40 pounds is reached, when it closes and does not open again until pressure in signal line is reduced below 40 pounds, when it opens again to maintain that pressure in line.

Q. 49.—Explain the operation of the whistle signal valve.

A. The whistle signal valve is a device divided into two compartments, separated by a rubber diaphragm. The diaphragm has a pin valve attached to the bottom of it which seats in a pipe leading to the cab. Air passes from the signal line and equalizes on both sides of the diaphragm. Should any reduction be made in the signal line, such as the opening of a coach valve by trainmen, the air escapes faster from the upper side of diaphragm than the lower, which causes it to raise, by expansion of air in lower part, raising pin valve from seat and allowing air to blow whistle in cab. See Fig 25,

Q. 50.—If the whistle signal blows when the brakes are being released, where would you look for the trouble?

A. A defective signal reducing valve.

MISCELLANEOUS

Q. 51.—Explain the operation of the quick action triple valve.

A. Brakes are released, and auxiliary reservoir re-charged, with brake pipe air passing into triple valve pushing piston and attached slide valve over, allowing air to pass into auxiliary, and brake cylinder air to escape to atmosphere, thus releasing brakes. By making a gradual reduction in brake pipe auxiliary air moves triple valve and slide valve back again to close feed groove, closes brake cylinder to atmosphere, and auxiliary air passes in to set cylinder brakes. A quick heavy reduction of brake pipe pressure moves triple piston and slide valve over as far as allowed, allowing auxiliary air to open emergency piston, which in turn allows brake pipe air to rush in and set cylinder brakes, at the same time brake cylinder is getting auxiliary air. See Figs, 14, 15, 16, 17, 18, 19, 20, 21.

Q. 52.—What additional features are found in the "K" triple that are not found in the older types of triples?

A. Brake pipe air is allowed to help set cylinder brakes in service application, and release of brakes is retarded by restricting discharge of cylinder air. See Fig. 22. Valve in release position.

Q. 53.—What is meant by quick service?

A. The venting of brake pipe pressure through the triple valve to brake cylinder makes the reduction of brake pipe air greater under each car, causing brakes to apply more quickly, whole length of train.

Q. 54.—What is meant by retarded release? How is it obtained, and in what part of train?

A. Retarded release means the release of cylinder brake air through a restricted part in triple valve. It is obtained by building up brake pipe pressure very rapidly, which moves triple valve to retarded release position, and is operative on about 30 first cars in train.

Q. 55.—Explain the operation of the high speed reducing valve.

A. This valve is connected with brake cylinder and its purpose is to reduce cylinder pressure in excess of 60 pounds fast enough to prevent wheels from sliding when a slower rate of speed is attained. With any pressure above 60 pounds cylinder pressure automatically escapes to atmosphere through a port which closes as soon as it is reduced to 60 pounds, retaining that much in cylinder. In 27 seconds, 85 pounds can be reduced to 60.

Q. 56.—What are the essential parts of the P. C. brake as applied to a passenger car?

A. One control valve and its reservoir, one service brake cylinder and its reservoir, one emergency cylinder and its reservoir. See Fig. 26.

Q. 57.—In making a service application with the P. C. brake, how low can the brake pipe pressure be reduced before emergency application takes place?

Q. 57.—If a service reduction is carried to one-half the original brake pipe pressure brakes will move to emergency position. For example, one-half of 110 pounds pressure, or one-half of 90 pounds pressure, or one-half of 70 pounds pressure, would be 55, 45 and 35 pounds.

Q. 58.—In making a service application what brake pipe reduction is necessary to insure the P. C. brake applying?

A. Eight pounds at least.

Q. 59.—When should the brakes be released after an emergency application from any cause; and when should you proceed?

A. Not until train has come to a stop. No attempt to move train should then be made until pressure in brake pipe has been raised to within 10 pounds of required amount.

Q. 60.—What is meant by an application of the brakes?

A. All reductions, from first to last, in brake pipe pressure until brakes are released.

Q. 61.—How many applications of brakes should be made when making a stop with a passenger train, and why?

A. Make two applications, to prevent sliding of wheels, and unsteady movement to cars.

Q. 62.—Explain how you would make an ordinary service stop with a long freight train. What should be the first reduction, and why?

A. Would place brake valve in service position and make a seven to ten pound reduction, watch movement of train as brakes apply. If train slows down smoothly would increase the reduction until total brake pipe reduction shows 20 pounds before releasing brakes. The first 7 to 10 pound reduction is to insure pistons moving by leakage grooves.

Q. 63.—Explain how a stop at a water tank or coal chute should be made with a long freight train.

A. Make one application and stop a short distance back. Leave brakes applied, and, if on a grade, apply enough hand brakes to hold train if air brakes should leak off. Cut engine from train and take coal or water.

Q. 64.—In making a stop with a freight train, why should the brakes not be released until stop is completed?

A. To prevent shocks from tearing train apart.

Q. 65.—In releasing brakes on a long freight train what should the engineman do to be sure that all brakes are released?

A. Place brake handle in release position and leave it there until brake pipe pressure is back to within five pounds of allowed pressure.

Q. 66.—If the brakes are dragging how can they be released from engine?

A. Make a brake pipe reduction, and then place handle of brake in full release long enough to release all brakes, moving handle to running position again. But with long train, exceeding 60 cars, and not moving faster than 15 miles per hour, would come to full stop.

Q. 67.—Why is it dangerous to repeatedly apply and release the brakes on grades without giving time for the auxiliaries to fully recharge.

A. It needs time to recharge auxiliary reservoirs, because ports in triple valves are small, and if not enough time is given between applications, auxiliaries will be robbed of air pressure, and braking power will be lost.

Q. 68.—What benefits are derived from the use of the retaining valve?

A. It holds small amounts of air in brake cylinders, which does some braking while auxiliaries are being recharged. Retaining valves are only used on roads having long, steep grades to descend.

Q. 69.—What does it indicate, when making a service application, if the exhaust port closes quickly, and the brakes go on hard?

A. An emergency application.

Q. 70.—When the brakes apply suddenly what should engineman do?

A. Close throttle and place automatic brake valve in lap position, to prevent loss of main reservoir air.

Q. 71.—In case a hose should burst while on the road, what should an engineman do to assist the trainmen in locating it?

A. After train has come to a stop, move brake valve, at short intervals, from lap to full release and back again, while in full release a blow will show at bursted hose.

Q. 72.—When double heading which engineman should have full control of brakes, and what should the other one do?

A. The man on head engine. And the one on second engine should close cut-out cock under brake valve.

Q. 73.—As a rule, how great a reduction of brake pipe pressure is necessary to insure the brake piston being moved by the leakage groove?

A. At least five pounds.

Q. 74.—From a 70 pound brake pipe pressure, how much of a reduction will be required to apply the brakes in full, and why?

A. A reduction of 20 pounds, and then brake cylinder and auxiliary reservoir pressure are equalized.

Q. 75.—What effect has the piston travel on the pressure developed in the brake cylinder?

A. A short piston travel develops more power than a long one.

Q. 76.—When should the brakes be tested?

A. As soon as locomotive is placed on train at terminal, or after an angle cock has been closed, and at points assigned for the testing of trains.

Q. 77.—How should the brake valve be handled when making a terminal test of brakes?

A. First make a reduction of 10 pounds and note the length of service exhaust. A further exhaust of 15 pounds should be made and brake held on until signal comes from rear to release. Then wait until an all right signal is given.

Q. 78.—What is meant by a running test; how and at what points on the road should it be made?

A. A light application of brakes made while train is in motion in order to determine their efficiency, after which they are released. It is made when approaching any place where brakes might suddenly have to be applied.

Q. 79.—What is the proper brake cylinder piston travel on engine and tender?

A. Driver brake piston not more than 5 inches, and tender and truck brake pistons not more than 6 inches.

Q. 80.—How is slack taken up on engine and tender brakes?

A. An adjusting screw on engine. On tenders a dead lever on each truck, and the lower connecting rod can be adjusted.

Q. 81.—How often should the main reservoir be drained, and why?

A. Before and after each trip, to get rid of water which may have accumulated, and which is taking up air space, and also which may freeze, and cause trouble in winter weather.

Q. 82.—What is a dead engine device, and when should it be used?

A. A device to operate locomotive brakes, when it is necessary to move engine in train and air pump is inoperative.

Q. 83.—Why is it important that piston travel be kept properly adjusted?

A. To provide a proper and even braking power.

Q. 84.—What danger would there be from a leak of main reservoir air to the brake pipe, brakes applied lap position?

A. Such a leak would eventually release brakes.

Q. 85.—Do you think it good practice to reverse the engine while the driver brake is applied, and why?

A. No. It would lock wheels, causing them to slide, and thus losing braking power.

QUESTIONS AND ANSWERS ON MALLET COMPOUND LOCOMOTIVES

Q. 1.—What is a compound locomotive?

A. One that uses steam two or more times.

Q. 2.—How many styles of compounds in use?

A. Three: Cross compounds, tandem compounds, and articulated compounds. The last commonly called "Mallet compounds."

Q. 3.—How many cylinders has an articulated compound?

A. Four, two high pressure, and two low pressure cylinders.

Q. 4.—Where are these cylinders located?

A. The high pressure cylinders are located, one on each side, about the middle of the boiler, and with the back set of drivers, attached to the frame and boiler in the usual manner.

Q. 5.—Where are the low pressure cylinders located?

A. One on each side, at front of boiler, and with the front set of driving wheels, attached to a frame, which is not rigid to boiler, but is secured to it by sliding bearings.

Q. 6.—What connects the front and rear frames?

A. A hinged connection, that allows the front set of wheels to swing when rounding a curve, making the front group practically a truck, and from this fact, it derives the name "articulated compound."

Q. 7.—What advantages are claimed for "articulated compounds"?

A. They can round same curves that shorter locomotives use, and have much more tractive power with no increase in axle load.

Q. 8.—How may an articulated compound be made to operate simple or compound?

A. By means of a reducing, an intercepting, and a separate exhaust sometimes called an emergency valve.

Q. 9.—Explain how a Mallet compound may be operated in simple position?

A. A valve is turned in engine cab which allows steam to pass in front of the emergency valve, forcing it open. In this position, all four cylinders are supplied with live steam from the boiler and the low pressure cylinders exhaust to atmosphere, and the high pressure cylinders exhaust to atmosphere through the receiver pipe and emergency valve.

Q. 10.—Explain how a Mallet compound may be operated in compound position?

A. The valve in the engine cab is turned to compound position. This allows steam to escape in front of emergency valve and it closes. Throttle is opened and passes steam to high pressure cylinders which exhaust direct from them to a receiver pipe gradually building up a pressure. Until this pressure is strong enough to automatically move the intercepting valve and allow receiver pipe pressure to operate the low pressure cylinders, they are operated by live steam from the boiler through a pipe and reducing valve. This reducing valve is forced open, by the live steam, and fills pipe leading to low pressure cylinders until its pressure is about one-half that of the live steam; then the reducing valve automatically closes on account of its greater exposed area, while in open position. As soon as low pressure cylinders exhaust, same operates again.

Q. 11.—When does a Mallet compound locomotive have the most power?

A. When operating as a simple locomotive, it has about 20 per cent more power than when in compound position.

Q. 12.—When should a Mallet compound be operated simple?

A. Only when about to stall, while working in compound position, or when starting a train that cannot be started with locomotive in compound position.

Q. 13.—When should a Mallet compound not be worked as simple engine?

A. When running faster than three or four miles per hour.

Q. 14.—What should be done when locomotive is drifting?

A. Cylinder cocks should be open and reverse lever placed in about ¾ stroke.

Q. 15.—How should intercepting valve be lubricated?

A. About one minute before starting it should be freely oiled, and periodically it should be oiled, if throttle has not been closed for a long time. Otherwise, one drop of oil every four or five minutes will suffice.

Q. 16.—What other parts, not found on simple engines, should be lubricated?

A. Sliding boiler bearings on head engine. Ball joint ahead of high pressure cylinder. Rear ball joint of exhaust pipe. Front ball joint of exhaust pipe. Bolt of articulation between two groups of wheels. Ball bearing of connecting bolts between frames. Piston rod packing of power reversing gear. Air cylinders of power reversing gear, once per week.

Q. 17.—How should cylinder and valve blows be located?

A. Compound should first be placed in simple position, and then blows can be located same as on simple locomotives.

Q. 18.—In case any cylinder should be disabled, what should be done?

A. Disconnect and block as usual. Then operate in simple position to destination, never running faster than three or four miles per hour.

Q. 19.—How high should water be carried in the boiler of a Mallet compound?

A. Never more than two full gauges, while working, to avoid its being carried into intercepting valve while throttle is open.

Q. 20.—How should valves and pistons be lubricated?

A. More oil should be fed to high pressure cylinders than to low, because the steam passes from high to low cylinders and necessarily carries some of the high pressure cylinder oil with it.

QUESTIONS AND ANSWERS ON ELECTRIC HEADLIGHT.

Q. 1.—Describe the passage of current through the lamp and tell how arc light is formed?

A. The necessary electric plant is made by having a shaft with a small dynamo at one end and a small turbine steam engine at the other. Steam is turned on in cab to operate turbine, and an even speed is maintained by means of a governor operated by centrifugal force. When the current is generated, it is carried to the lamp stand and back to the dynamo, by means of insulated copper wires. The current, passing from dynamo to lamp, is called the positive, and when passing back from lamp to dynamo it is termed the negative current. The positive current starts from a post attached to the dynamo brush, and enters the lamp at a binding post on the standard. From there it passes up through a series of wires and levers, until it reaches top of carbon. It then passes down through carbon and copper electrode. From the bottom of the electrode it passes through the solenoid, and back to the negative binding post on stand, and then to the opposite brush on dynamo from where it started. The current has now completed a circuit. The act of passing through the solenoid magnetized it, and drew it down in dash pot, causing a series of levers and springs to separate points of carbon and electrode. The positive current is now obliged to jump from the carbon to electrode and enough friction is generated by this act to make what is known as electric light. See Fig. 27.

Q. 2.—Why should sand paper be used to smooth commutator instead of emery cloth?

A. Because emery is a conductor of electricity, and any deposit of it between copper sections of commutator is liable to short circuit it. Sand is a non-conductor of electricity.

Q. 3.—State how to focus a lamp?

A. By means of screw at back of reflector, so reflector will line up with edges of case.

Q. 4.—If the light throws shadows upon the track is it properly focused?

A. It is not. The edges of the case are out of line with reflector.

Q. 5.—If the light is properly focused, that is, if the rays are leaving the reflector in parallel lines, but the light does not strike center of the track, what should be done?

A. The headlight case is not in line with engine and should be shifted until it is.

Q. 6.—What can be done to insure a good and unfailing light for the whole trip?

A. See that carbon is properly secured, and of sufficient length. Make sure that electrode is free from slag at point. See that commutator is properly cleaned and that brushes are properly shaped to match contour of commutators. See that all wires are properly fastened and insulated. Have oil in bearings of dynamo and engine boxes. In fact, make thorough inspection of all equipment.

Q. 7.—How much oil and what kind should be used in the bearings of an electric headlight equipment?

A. The best grade of engine oil furnished. It should be used on both bearings and just enough in each oil box so ring will carry to bearing.

Q. 8.—Why should not the main oil cellars be full of oil?

A. Oil will run out of overflow holes and cover equipment, destroy insulation and cause short circuits.

Q. 9.—Why should valve oil not be used in oil cellars?

A. It is too heavy for the oil rings to carry to bearings, and in winter time it would be still more so.

Q. 10.—What part of the dynamo should receive the closest inspection?

A. The commutator.

Q. 11.—What care should it receive?

A. The commutator is built in sections, divided by thin pieces of mica which act as an insulation. The edges of the mica sheets should be kept filed slightly lower than the copper plates they separate.

Q. 12.—How and when should the commutator be cleaned?

A. Before the commencement of any trip, a damp piece of waste should be used to wipe the commutator lengthwise, and then it should be wiped dry with clean waste.

Q. 13.—What kind of bearing should the brushes have on commutators?

A. Bearings should have the same circular contour as the commutator, and should be thick enough to cover the faces of at least two sections at a time.

Q. 14.—How are brushes fitted?

A. While dynamo is not working, take a piece of the finest sand paper, and make it as wide as the sections of the commutator are long. Then wind it around commutator with rough side toward brush. Shove brush up towards commutator and pull strip of sand paper back and forward until desired bearing is made. Now file off front sharp edge of brush 1/16 or 1/8 inch.

Q. 15.—Is it permissible to try and fit a brush with a knife or file?

A. No. Because it cannot be done.

Q. 16.—What must be cleaned off the copper electrode each trip?

A. A glassy scale, which is made from clinker in the carbon, which under intense heat melts and runs down on point of electrode.

Q. 17.—How should copper electrode be trimmed at point?

A. It should have a circular apex about 1/8 or 3/16 inch wide.

Q. 18.—How high above holder should electrode be allowed to stand?

A. About one inch.

Q. 19.—What might happen if electrode be allowed to stand above holder more than an inch?

A. It might bring the point too near the clutch that holds the carbon, and the intense heat would cause serious damage to the top carbon holder and clutch.

Q. 20.—What regulation should be given to spring running from stand to one of the solenoid arms or lever?

A. When engine is standing this spring should be set, so light will just flicker or flash, and then when engine is in motion this spring will become strong enough to steady the light.

Q. 21.—If this spring should be tightened so light would be steady while locomotive is standing, what would happen while under high speed?

A. A movement would be imparted to the tension spring which would release the clutch just enough to allow carbon to drop, and shorten distance between it and the electrode, which would cause the lights to dim.

Q. 22.—Is there anything else that would cause the light to dim down when the engine is running fast?

A. Yes. If the spring that holds the heel of the clutch should become weak, it would allow the clutch to drop, taking the carbon with it, and rest on top of electrode. The lights would go out.

Q. 23.—If light burns all right when engine is in motion, but goes out when engine is stopped, what would be the trouble?

A. The solenoid tension spring is almost always found to be too weak, but sometimes the plunger in the dash point becomes corroded and gives the same effect as a weak tension spring.

Q. 24.—If the plunger in the dash pot should become stuck, should one put oil in it?

A. No. It should be cleaned with coal oil and then afterward wiped dry.

Q. 25.—If the carbon in lamp should jig or pound, what can be done to stop it?

A. This is an indication that the plunger in the dash pot is too long, and must be lengthened by adding a link to chain inside of dash pot.

Q. 26.—How far would it be necessary to drop plunger in dash pot to stop pounding?

A. About one-half of an inch.

Q. 27.—Does pounding of the lamp occur with the old series wound machines or with the new compound wound machines?

A. With the new compound machines.

Q. 28.—If the copper electrode commenced to fuse, how would it be known?

A. It would show a green light.

Q. 29.—What should be done when a green light is seen?

A. Shut off steam to dynamo until white light appears.

Q. 30.—What causes the copper electrode to fuse?

A. Too high speed; or should the positive current wire be connected to it, by error, that too would cause it to fuse.

Q. 31.—What arrangements have been made to prevent the wrong connection of wires?

A. The positive binding posts on dynamo, and also on lamp standard, are supplied with larger holes for wire connections than the negative posts, and all ends of positive wires are bent back in order to make them double, to fill larger sized hole.

Q. 32.—Should the copper electrode and holder become useless while on the road from fusing, what can be done?

A. A piece of carbon, or an iron bolt, of right length can be fastened in clamp from which holder is removed. Care must be taken to have bolt or carbon come to center of reflector, and not rest on bottom of it, or lamp.

Q. 33.—If while running along with light burning steadily and nice, it should begin to flash badly and keep it up, where should one look for the trouble?

A. The binding posts should be examined for loose screws.

Q. 34.—If while running along with good, steady light, it should suddenly go out, where should one look for the trouble?

A. It would be a burnt out carbon, a broken lead wire, or wire broken, or entirely loose from binding post.

Q. 35.—If the light should go out while between stations, what ought the engineer to do?

A. Shut off steam from equipment, hang white light to front of locomotive, and locate trouble at first stopping place.

Q. 36.—Why is it necessary to shut off steam and stop equipment?

A. Because the trouble might be caused by a short circuit, which might heat and burn out coils, or armature, of dynamo.

Q. 37.—How does equipment act when short circuited?

A. Engine labors hard and the exhaust of steam from turbine will be heavy. There will be no lights either in cab or headlight, but the carbons in all lamps will show a dull red..

Q. 38.—How will the equipment act when circuit is broken, either by a broken or disconnected wire, or a burned out carbon?

A. The equipment will run very fast, and not exhaust much steam from turbine. There will be an absence of noise.

Q. 39.—How should one test for a broken circuit?

A. Would place a piece of carbon from one binding post to other on dynamo; if a spark is seen, dynamo is all right. Would then test, from one binding post to the other, on lamp. If a spark does not show, trouble is in wires between dynamo and lamp. If spark does show, then trouble is in lamp, because both dynamo and wires have tested all right.

Q. 40.—How would one proceed to locate point of trouble with a short circuit?

A. After testing, from one binding post to the other, on dynamo and finding it all right, and by testing from one binding post to other on lamp and finding trouble in wires, would disconnect positive wire from binding post on lamp and touch end to negative post on dynamo and watch for spark. Then disconnect wire from negative binding post on lamp and touch end to positive post on dynamo and watch for flash. If either wire refuses to spark, then the trouble is there. If both wires refuse to spark, then both are wrong.

LOCOMOTIVE SMOKE CONSUMER.

Q. 1.—What is a smoke consumer?

A. A device that blows jets of steam into a firebox through holes in legs of boiler.

Q. 2.—What is the result of this operation?

A. As the steam passes through holes in legs of boiler, air currents into firebox are induced, which furnish oxygen for the consumption of any gases being liberated from fresh coal on the fire. At the same time the jets of steam have a tendency to hold in the firebox unburned particles of lamp black, resins, etc.

Q. 3.—What is necessary when operating a smoke consumer?

A. That it always be assisted with the blower.

Q. 4.—When should a smoke consumer be used?

A. When operating engines in and about cities or other places where smoke is especially offensive and a fireman finds that even by skillful firing he cannot avoid black smoke, then he must make use of the smoke consuming device.

Q. 5.—Describe in a general way a smoke consumer on a locomotive, and its operation.

A. In Figure H, let A represent the steam turret on top of boiler head. Letters BB, piping for blower, and C, piping for smoke consumer. Then DD represent blower valves, and E shows location of smoke consumer valve.

The steam jets and location are represented by the letters F. First, open wide the valve in top of blower pipe. Then open second blower valve and also smoke consumer valve as wide as necessary to consume black smoke.

It will be noted that with this style of consumer, it is impossible to use it without also using the blower.

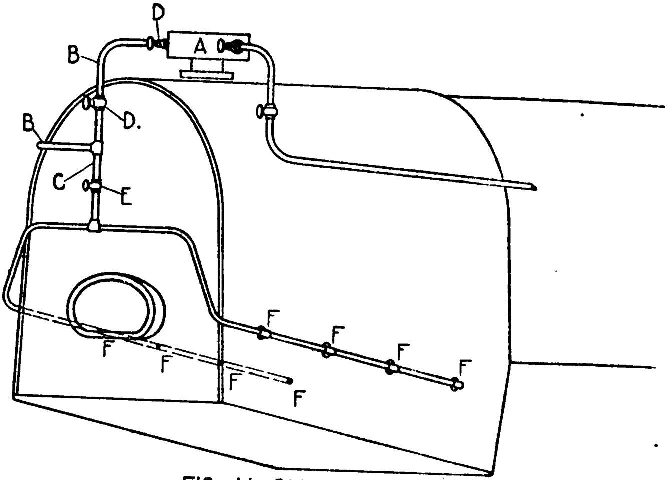


FIG. H SMOKE CONSUMER

NAMES OF PARTS	
A	STEAM TURRET
B	PIPING FOR BLOWER
C	PIPING FOR SMOKE CONSUMER
D	BLOWER VALVES
E	SMOKE CONSUMER VALVE
F	STEAM JETS

OIL BURNING LOCOMOTIVES.

Q. 1.—What is an oil burning locomotive, and where is it most generally used?

A. A locomotive that burns fuel oil instead of coal or other fuel, and is mostly used in localities where the long freight haul of coal makes its cost excessive.

Q. 2.—What is fuel oil?

A. Crude petroleum, or in some cases, the residue that is left after crude petroleum has been refined.

Q. 3.—How do crude oils differ?

A. All crude oils contain a solid base or residue, composed of hydro-carbons. In Pennsylvania, Ohio and West Virginia, the base is a heavy paraffine, but in California, Texas and other western states it is a heavy asphalt. The crude oils with a paraffine base contain about 75 per cent of high-grade oils, such as naphtha, benzine, gasoline and kerosene, which only leave about 25 per cent of product fit for fuel oil. But the crude oils with an asphalt base contain so little of these high-grade oils that it does not pay to refine them; consequently, the product is almost entirely used for fuel.

Q. 4.—What is the meaning of the flash point of crude oil?

A. It is the lowest point of temperature at which the oil will ignite.

Q. 5.—What should be the flash point of crude oil for safety?

A. Minimum temperature of 140° Fahrenheit, preferably 150° F.

Q. 6.—How does crude oil compare in value with coal for locomotive fuel?

A. According to exhaustive tests made on a western railroad, it was found that it takes about three and one-half (3½) barrels of fuel oil to equal one ton (2000 pounds) of coal.

Q. 7.—Can oil be consumed with satisfactory success in the same type of firebox, grates, etc., as coal?

A. No. In the early history of burning oil on locomotives, it was used in the coal burning type, but the grates allowed too much cold air against the flues, and the oil flame direct against the firebox sheets did not give good results.

Q. 8.—What was done to remedy conditions?

A. The grates were done away with, and a closed pan is now used with a burner and air inlet at front end. The firebox is made very large and fire-bricked on sides and back end so that flame from burner in front of pan is projected

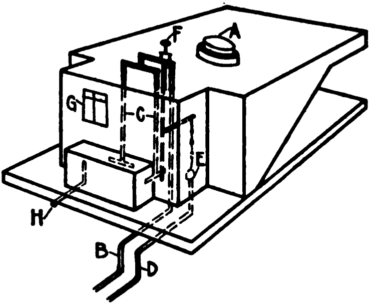


FIG. MI OIL TANK & PIPING.

NAMES OF PARTS	
A	MAN HOLE TO OIL TANK
B	HEATER PIPE FROM LOCOMOTIVE
C	HEATER PIPE INSIDE OF OIL TANK
D	OIL SUPPLY PIPE TO LOCOMOTIVE
E	OIL SUPPLY PIPE VALVE
F	MEASURING ROD TO OIL TANK
G	CAPACITY PLATES ON OIL TANK
H	PIPE TO DRAIN WATER FROM TANK
I	SAND BOX FOR CLEANING FLUES

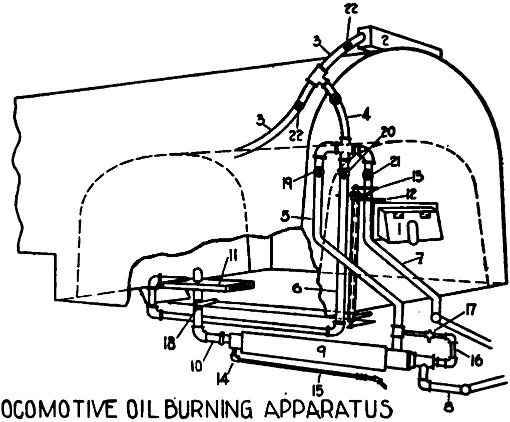


FIG. M2 LOCOMOTIVE OIL BURNING APPARATUS

NAMES OF PARTS			
1	OBSERVATION FIRE DOOR	12	HANDLE TO VALVE 18
2	STEAM TURRET	13	HANDLE TO DAMPER
3	BLOWER PIPE	14	WASTE PLUG TO SUPERHEATER JACKET
4	OIL BURNING PIPE	15	PIPING FOR WASTE PLUG
5	SUPERHEATER PIPE	16	BLOW BACK PIPING
6	ATOMIZING PIPE	17	BLOW BACK VALVE
7	HEATER PIPE	18	OIL VALVE TO BURNER
8	OIL PIPE FROM TANK	19	SUPERHEATER PIPE VALVE
9	SUPERHEATER	20	ATOMIZER PIPE VALVE
10	OIL PIPE TO BURNER	21	TANK HEATER PIPE VALVE
11	BURNER IN FIRE BOX	22	BLOWER PIPE VALVE

against bricks in back of firebox, and it rebounds towards flues. This prevents bad effects of oil flame against sheets and at same time more thoroughly mixes the air and hydrocarbons, causing a better state of combustion.

Q. 9.—Describe in detail the apparatus for burning crude oil on a locomotive.

A. Let Figure M-1 represent the oil tank and its pipings, and Figure M-2 the oil burner pipings on the locomotive boiler head and firebox. Figure M-1 shows the shape of the oil tank, which is designed to fit in the coal pit space in tender of a coal burning locomotive. Let A show manhole of tank which is provided with tight fitting covers, and also wire gauze screen to prevent dirt and refuse from entering when oil is placed in tank. Pipe B allows steam to flow from locomotive boiler to pipes CC. These pipes are on inside of oil tank and are provided with open end tees at their bottom ends, which allow the steam to enter oil and heat it in the vicinity of pipe D. This pipe, when valve E is opened by means of a handle and chain, allows oil to pass to locomotive. Letter F shows where measuring rod is located, and G shows plate on oil tank which indicates its capacity, and also number of gallons per inch. Valve E is placed a few inches above the bottom of tank so that when steam from pipes B, CC condenses it will not flow to engine, but is drawn off by means of pipe H, whose mouth in oil tank is placed flush with bottom of tank floor.

In Figure M-2, let 2 show turret on boiler head, and 3 blower pipe leading from same; 4 shows oil burning pipe connected with blower pipe in such a manner that it can be operated with blower or independent of it; 4 pipe is divided into three pipes, 5, 6 and 7. Pipe 7 connects with pipe B on tank, and pipe D on tank connects with pipe 8 on locomotive. These are the only oil burning device pipes between tank and engine, and are provided with flexible metallic piping, as rubber will not provide safety. 9 shows what is known as a superheater, which is a steam jacket surrounding the oil pipe which leads to burner 11, in firebox, and heats the oil on its way to the burner. Pipe 10 leads from superheater to burner, which is placed in front end of firebox with mouth away from flues. 12 is handle in cab that regulates flow of oil to burner, and 13 is handle in cab that regulates damper just ahead of burner. There is a connecting clasp between these two handles, so they can be set to open together or closed in same manner. 14 shows location of valve on lower front end of superheater, and takes care of any condensation which may form in superheater. It is so arranged that this is allowed to pass out through pipe 15 and does not interfere with view of engineman. 16 is known as the blow-back pipe, and 17 is the blow-back valve. 18 is oil regulating valve, and is operated in cab by means of handle 12.

Q. 10.—Describe operation of oil burner.

A. First, know that all oil burning pipes are tight and that no oil is dripping and that there is no accumulation of oil in firebox, which might explode and burn whoever starts fire.

To operate oil burning device there must be at least ten pounds of steam in boiler. At engine houses, where steam is available, it can be used through blower piping to start fire and raise pressure up to ten pounds in boiler. But if at points where steam pressure is not available, then fire must be started with wood until steam shows in boiler to the extent of 10 pounds. When using wood, care should be exercised that firebricks in firebox are not injured. When ten pounds shows on steam gauge, turn on atomizing valve 6 and blow out any condensation that may have accumulated in burner. At the same time turn valve 21 in pipe 7, which will allow steam to pass to tank heater. Close atomizer valve and throw a piece of oil saturated and lighted waste in back end of firebox, open atomizer valve slightly, and carefully turn on oil at tank valve, and then by means of handle 12 in cab, allow a small amount of oil to go to burner, where it will be sprayed on burning waste by the atomizer and will burst into a flame. Now open damper in front end of closed ash pan by means of handle 13 in cab, and regulate oil, atomizer and damper according to the nature of the work, taking care to raise temperature in firebox slowly and not burn too much oil for the amount of air supply, or dense black smoke will result.

Q. 11.—If there is any obstruction in oil pipe or burner, how can it be blown out?

A. By closing oil feed valve E on tank, and waste valve 14 on superheater. Open oil regulating valve 18 and blow back valve 17. Then open superheater valve 19 wide enough to blow out obstruction.

Q. 12.—How can an obstruction be blown out of oil feed pipe from tank?

A. Close oil regulating valve 18 and waste valve on superheater 14. Open valve E on tank and valve 17 on blow-back pipe. Then open superheater valve 19, which will allow steam from pipe 5 to pass back into tank, blowing out the obstruction.

Q. 13.—What care must be exercised in and about the oil tank?

A. No flaming light should be near when filling oil tank, and none should ever be placed inside a tank until it has been emptied and thoroughly washed.

Q. 14.—How should the heaters be used?

A. The tank heater should be used just enough to make the oil flow freely to locomotive, and the superheater should be used just enough to make the oil atomize freely.

FEDERAL REGULATIONS FOR SAFETY APPLIANCES.

Q. 1.—What constitutes a safety appliance, as applied to a locomotive?

A. Such parts of a locomotive as are especially constructed and applied with a view of protecting against personal injury, employes whose duties require them to work on or about the engine.

Q. 2.—Name some of the safety appliances found on a locomotive.

A. The air brake, steps, ladders, handholds and hand rails, couplers and coupler operating levers, etc.

Q. 3.—In what condition should safety appliances be maintained?

A. They should be maintained in perfect condition.

Q. 4.—What should be done in event of any of the safety appliances being damaged while engine is in service so as to render it unsafe?

A. It should be reported at once to some person in authority who can relieve the engine from service until the necessary repairs are made.

Q. 5.—What effort should be made on the part of the engineer to prevent persons using a safety appliance which he knows is damaged and unsafe?

A. He should warn all persons on or about the engine who are liable to use the damaged part, of its unsafe condition.

Q. 6.—What is the duty of the engineer in event of his discovering a safety appliance which is in an unsafe condition when taking an engine from roundhouse territory?

A. He should at once call the attention of roundhouse foreman or one of his assistants to the condition of this safety appliance, so that necessary repairs can be made before the engine is allowed to go into service.

FEDERAL REGULATIONS FOR INSPECTION OF LOCOMOTIVES AND LOCOMOTIVE BOILERS.

Q. 1.—What is the purpose of the Federal Rules and Regulations for inspection of Locomotives and Locomotive Boilers?

A. To provide a uniform requirement for inspection, maintenance and operation of locomotives on all railroads operating within the United States.

Q. 2.—Whom does the Federal Government hold responsible for the general design, construction and safe working pressure of locomotive boilers; also the general design, construction and maintenance of locomotives and tenders on a railroad?

A. The railroad company will be held responsible for the general design and construction of locomotive boilers, and also, under a ruling approved March 4, 1915, it will be responsible for the general design and maintenance of its locomotives and tenders.

The safe working pressure of each locomotive boiler shall be fixed by the Chief Mechanical Officer of the company, or by a competent Mechanical Engineer under his supervision.

The Mechanical Officer in charge, at each point where boiler work is done, will be held responsible for the inspection and repair of all locomotive boilers and their appurtenances under his jurisdiction.

The Mechanical Officer in charge, at each point where repairs are made, will be held responsible for the inspection and repair of all parts of locomotives and tenders under his jurisdiction.

The inspection, as used in these rules, unless otherwise specified by Federal Government, will be made by railroad company's inspectors, and all inspection reports from them must be signed after personal inspection.

Q. 3.—What is sometimes required of an engineer?

A. At points where no regular inspectors or maintenance forces are employed the engineman in charge of the locomotive terminating at such point shall make out inspection reports and every twenty-four hours forward reports to point where locomotive is maintained.

Q. 4.—What is the purpose of the monthly and annual Interstate inspection cards placed in cab of every locomotive?

A. To enable enginemen and Federal Inspectors to see that monthly and annual inspections have been made.

Q. 5.—What does the monthly card show?

A. 1.—What pressure safety valves have been set to carry.
2. When safety valves were last tested and left in good condition.
3. When boiler was washed, gauge cock and water glass cock spindles removed and cocks cleaned.
4. When both injectors were tested and left in good condition.
5. All steam leaks repaired.
6. Condition of flues and firebox sheets.
7. Condition of stay-bolts and crown stays.
8. The number of crown and stay-bolts removed.
9. The condition of arch or water bar tubes.
10. The date of previous hydrostatic test.

Q. 6.—What does the annual card show?
1. Date of previous hydrostatic test.
2. Date of previous removal of caps from flexible stay-bolts.
3. Date of previous removal of flues.
4. Date of previous removal of all lagging.
5. Hydrostatic test pressure of (pounds applied).
6. Were caps removed from all flexible stay-bolts?
7. Were all flues removed? Number removed.
8. Condition of interior of barrel.
9. Was all lagging removed?
10. Condition of exterior of barrel.
11. Was boiler entered and inspected?
12. Was boiler washed; water glass cocks and gauge cocks cleaned?
13. Condition of crown stays and staybolts.
14. Condition of sling stays and crown bars.
15. Condition of firebox sheets and flues.
16. Condition of arch tubes.
17. Condition of throat braces.

18. Condition of back head braces.
19. Condition of front flue sheet braces.
20. Were fusible plugs removed and cleaned?
21. Were steam leaks repaired?
22. Were steam gauges tested and left in good condition?
23. Safety valves set to pop at —— (lbs.) —— (lbs).
24. Were both injectors tested and left in good condition?
25. Were steam leaks repaired?
26. Hydrostatic test of (lbs.) applied to main reservoir.
27. Condition of brake and signal equipment.
28. Were drawbar and drawbar pins removed and inspected?
29. Condition of draft gear and draw gear.
30. Condition of driving gear.
31. Condition of running gear.
32. Condition of tender.

Q. 7.—When must these cards be placed in locomotive cabs?

A. Before a new boiler is placed in service, and each calendar month afterward, a monthly report card must be placed in cab, excepting the month when annual report is posted. At such times the monthly card is not required.

CARE OF BELL RINGER.

This is a duty that usually devolves on the fireman, and the better the condition of the bell ringer, the less annoyance it is to him while on the road.

Bell ringers usually work well for some time after the engine comes out of the shop, and then gradually it begins to cause trouble by stopping, or if not that, it will insist on turning the bell "over and over," and it is very often the case that during the last few months the engine is in service, before going in for repairs, that the bell ringer, instead of being a help to the men on the engine, is a positive source of worry and annoyance. This is not as it should be. A bell ringer that is in good order when the engine comes out of the shop, should be in fair condition when the engine is again worn out, providing that it has had good usage. The chief abuse to which the bell ringer is subjected is in the manner of lubrication. The oil cup usually provided for this is simply a tee in the air pipe with a plug in the free end,. and here is where the trouble comes in. When the bell ringer is oiled, the oiler figures that he must put enough in to "take her over the road." The result is that he pours in enough, it is safe to say, to run a nine and a half inch air pump four hundred miles. If one who oils a bell ringer would stop to think that all the oil, more than enough to lubricate the walls of the cylinder, will pass through the exhaust into the front end during the first few minutes that the ringer is working, the folly of the practice would be apparent to him. The result of this heavy oiling is that the little exhaust pipe is soon nearly full of "coked" oil, and the exhausting air from the ringer is retarded to that extent, that it does not get out in time to allow the piston to drop promptly under the weight of the bell. Then you think you are giving it too much air and ease it off accordingly, and after a swing or two the bell stops ringing, and you try it again with the same result, and finally get angry and ring the bell by hand to the end of the run. The engineer reports "bell ringer don't work." The man who does that class of repairs, after the engine is put in the house, with perhaps sixty pounds of steam, tries the ringer and finds, to his own satisfaction, at least, that the engineer is "off," and marks it off the book, and so on to the end. To avoid all this, when you oil the ringer put in two or three drops of engine oil (not valve oil), and you will see the benefit of your good judgment later on.

LUBRICATION IN CASE OF DISABLED VALVE GEAR.

In the following paragraphs, which treat of disabled valve gear, it is recommended in many cases to block the valve in central position, covering the ports, or to take other methods for shutting off the supply of steam from one cylinder, and proceed without taking down the main rod. In such case it is necessary to provide for the lubrication of the cylinder. This may be done by removing one of the indicator plugs, and oiling through the opening, or you may slack off the nuts on the front cylinder head, drive a wedge between the cylinder head and cylinder, to hold it open and prevent its slapping, and drop oil through this opening.

CYLINDER AIR VENTS IN CASE OF DISABLED VALVE GEAR.

In the following paragraphs on break-downs in which it is advised to shut steam out of one of the cylinders, by blocking the valve or other means, and proceed without taking down the main rod, it is very necessary to open each end of the cylinder to the atmosphere in order to prevent compression and vacuum in the cylinder as the piston moves back and forth. This may be accomplished in several ways. The cylinder cocks may be blocked open or removed on the disabled side, or the indicator plugs, or relief valves, if used, may be taken out.

STEPHENSON VALVE GEAR.

Figure I-1 is an illustration of a type of Stephenson valve gear, with direct motion, with inside admission piston valve. For the sake of clearness we have shown only one eccentric and connections.

BROKEN PARTS WITH STEPHENSON VALVE GEAR.

Broken Slide Valve or Attachments.

In this case it is necessary to disconnect the valve stem from the rocker arm, remove broken parts so far as necessary, shut off the supply of steam from the cylinder on the disabled side, and proceed, using one side of the engine.

In case the valve stem is not removed it must be sprung enough to one side to prevent the rocker arm from striking.

Just how to proceed to shut off steam from the disabled side will depend upon the conditions in each particular case. If the valve is in such condition that it can be made to cover the ports, place the valve in central position, covering the ports, and fasten it in that position by any means that may be practicable. If the engine carries a valve stem clamp, you may fasten the valve stem in the desired position by means of the clamp. If the valve stem is broken inside the valve chest on an engine equipped with steam chest relief valves, the valve may be held in position by driving a wedge into the gland, or using valve stem clamp for preventing backward motion of the valve; forward motion of the valve must be prevented by removing the steam chest relief valve, inserting a piece of wood of the proper length (a piece of broom handle will do), and replacing the relief valve in position.

Another method is to take up the steam chest cover and block the valve securely on all sides and on top, then put on the steam chest cover and screw it down until it makes a

NAMES OF PARTS			
1	MAIN ROD	14	VALVE MOTION ROD HANGER
2	MAIN ROD STRAP	15	LINK
3	ECCENTRIC ROD	16	LINK HANGER
4	ECCENTRIC CAM	17	ROCKER SHAFT
5	ECCENTRIC STRAP	18	REVERSE SHAFT ARM CENTER
6	CROSSHEAD	19	REVERSE SHAFT ARM END
7	CROSSHEAD WRIST PIN	20	REVERSE LEVER
8	PISTON ROD	21	REACH ROD
9	VALVE ROD	22	FRONT CYLINDER HEAD
10	VALVE ROD GUIDE	23	BACK CYLINDER HEAD
11	VALVE STEM	24	FRONT STEAM CHEST COVER
12	VALVE	25	BACK STEAM CHEST COVER
13	VALVE MOTION ROD	26	MAIN CRANK PIN

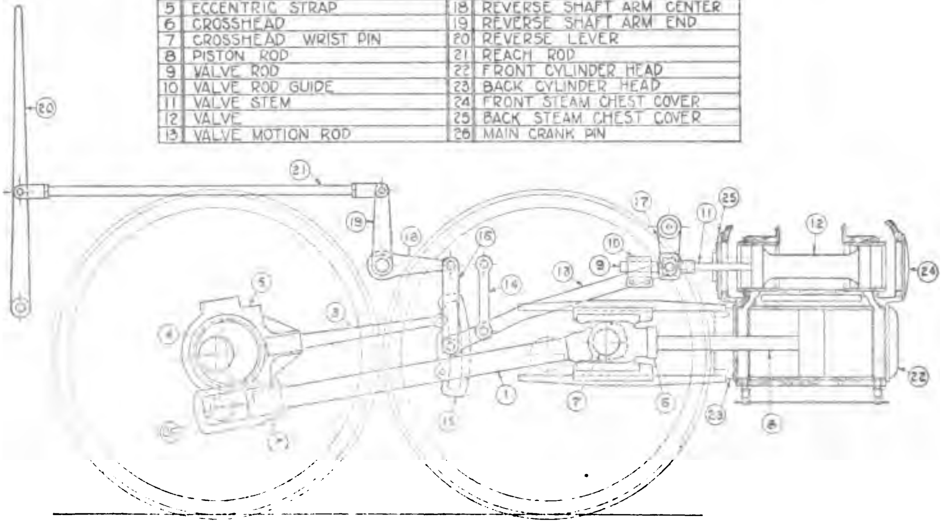


FIG. I1 STEPHENSON VALVE GEAR

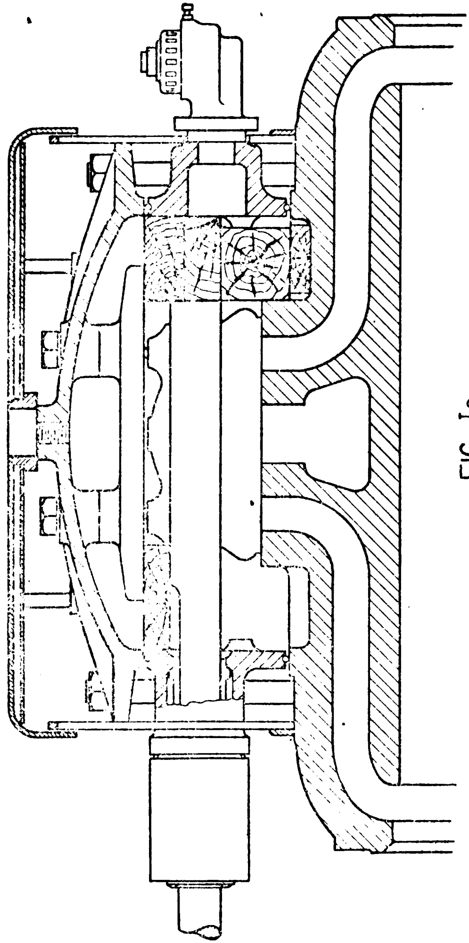


FIG. 12

joint; at the same time be sure that the block on top of the valve is thick enough so that when the cover is down it will be held tightly in position. With the balanced valve it will only be necessary to block the valve front and back, as shown in Figure I-2.

However, in case the valve is broken so that it cannot be used to cover the ports, cover all of the ports with layers of planking, laying the same so that the grain of the bottom layer is across the ports, and the grain of alternate layers is at right angles. Fill the steam chest up to the cover so that when the cover is screwed down it will hold the planking solid.

Having covered the ports, either by blocking the valve in central position, or by covering the ports with planking, you must open or remove the cylinder cocks, make proper provision for the lubrication of the cylinder, and you are ready to proceed. It is not necessary to take down the main rod and block the piston.

The only exception I would make to the above is where the steam pipe and steam chest are connected by a neck-joint between chest and smoke arch. In this case it has been my experience that the easiest way "out" is to loosen up the steam chest studs, then uncouple the "neck-joint," take out the rings and substitute a piece of board and a piece of old shovel blade (the shovel blade toward the smoke arch), pull up the joint bolts tight and go along. "Time is money!"

Broken Piston Valve or Attachments.

If a piston valve is broken, handle the same as a broken slide valve in so far as concerns disconnecting valve rod, etc. The valve should be fastened in central position, as described under "Broken slide valve," by clamping the valve stem, or blocking with pieces of wood. Figure I-3 is an illustration of a piston valve blocked in central position by means of pieces of wood.

Now open or remove cylinder cocks, make provision for lubrication of the cylinder and you are ready to proceed.

In case the valve or steam chest is damaged in such a way that steam cannot be prevented from blowing to the atmosphere, either directly or through the exhaust, the engine is usually entirely disabled, except in case the amount of steam escaping is so small that it does not interfere with vision or with maintaining steam pressure.

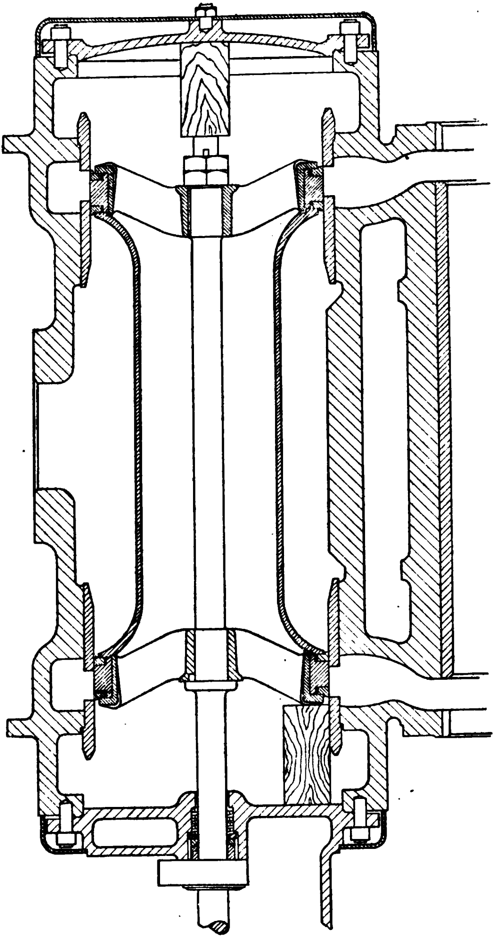


FIG. 13

Broken Slide Valve Seat.

The manner of determining whether or not you have a broken valve seat is as follows: Ordinarily it is the bridge between the steam and exhaust port that breaks, because it is of necessity narrower than the outside walls of steam ports. When you have reason to believe that a valve seat is broken, place the engine on the quarter, set up the brake, put the lever in the front notch and give the engine steam. Then if there be no "blow," put the lever in the back notch and open the throttle again, and if still no "blow," try the other side in the same way.

In the opinion of the writer, the simplest and easiest manner of handling this failure is to take off the valve chest cover and remove the valve and attachments complete. Now plug the ports with blocks of wood, fill the valve chest with pieces of wood and screw the cover back in place, as described in paragraph on "Broken Slide Valve."

Now open or remove the cylinder cocks, make provision for lubrication of the cylinder and proceed.

Broken Reach Rod.

When this occurs, remove or tie up the reach rod so that it will not interfere with the moving parts. Now cut one block long enough so that when it is put in the top end of link above the block, that link will be high enough so that the engine will cut off at about one-half stroke or longer stroke, if necessary; then in case it should be necessary to back up, on the trip home, cut a block, that if put in the same position, would hold the link clear up to the limit and put it in the tool box, where it will be handy.

Never block both links, because when the engine is running only one of them at a time would carry any of the weight, owing to the back and forward stroke of the rocker-arms, and the constant pounding caused by the weight shifting from one to the other several times in a revolution would have a tendency to work them out or pound them to pieces. One block is better, and the opposite link is then held up by both lifters and the tumbling shaft. "Time is money!"

Broken Saddle Pin, Lifter or Tumbling Shaft Arm.

When a saddle pin, lifter or tumbling shaft arm breaks on the road, either or any of them can be handled as follows: First, remove all broken parts to avoid further trouble, then

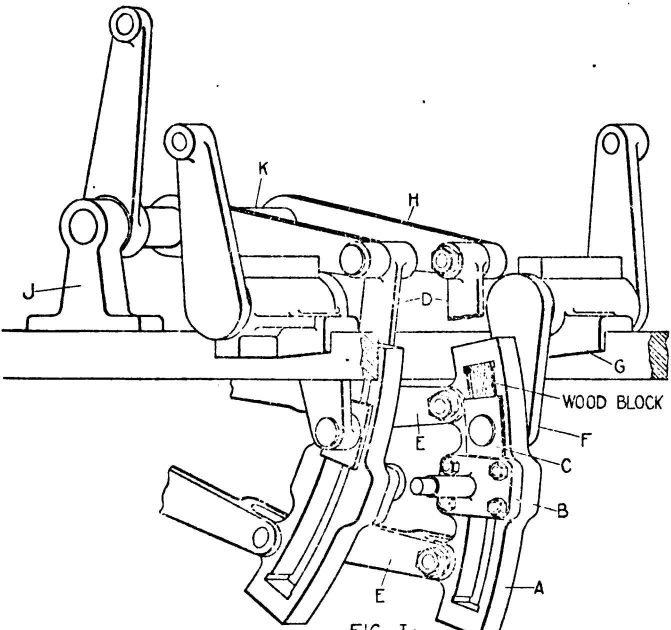


FIG. I4

NAMES OF PARTS			
A	LINK	F	ROCKER SHAFT
B	LINK SADDLE	G	ROCKER SHAFT BEARING
C	LINK BLOCK	H	REVERSE SHAFT ARM
D	LINK LIFTER	J	REVERSE SHAFT BEARING
E	ECCENTRIC ROD	K	REVERSE SHAFT

NAMES OF PARTS			
1	MAIN ROD	13	VALVE STEM
2	MAIN ROD STRAP	14	VALVE
3	ECCENTRIC ROD	15	RADIUS BAR
4	ECCENTRIC CRANK	16	RADIUS BAR LIFTER
5	UNION LINK	17	LINK
6	CROSSHEAD	18	REVERSE SHAFT LIFTING ARM
7	CROSSHEAD ARM	19	REVERSE LEVER
8	CROSSHEAD WRIST PIN	20	REACH ROD
9	PISTON ROD	21	MAIN ROD CRANK PIN
10	COMBINATION LEVER	22	FRONT CYLINDER HEAD
11	VALVE STEM CROSSHEAD	23	BACK CYLINDER HEAD
12	VALVE STEM CROSSHEAD GUIDE	24	FRONT & BACK STEAM CHEST COVER

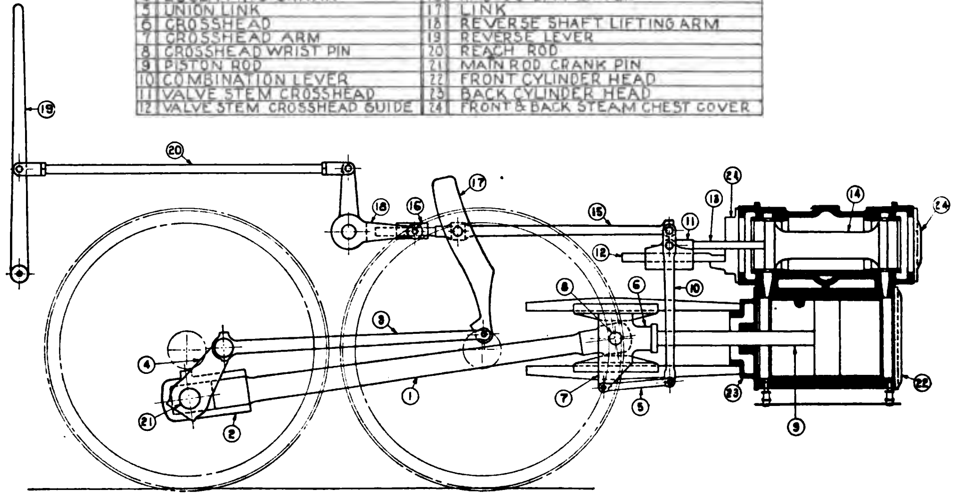


FIG. J1 WALSCHAERT VALVE GEAR

place the lever in a notch in the quadrant where you are reasonably sure you can start the train, then get underneath and raise the disconnected link to about a level with the other one, and put in a block that will carry it there; at the same time cut a block long enough to hold the link clear up in case you want to back up at any time. Figure I-4 shows link on disabled side blocked at same height as link on good side.

WALSCHAERT VALVE GEAR.

Figure J-1 shows a modern type of Walschaert valve gear with inside steam admission.

BROKEN PARTS WITH THE WALSCHAERT VALVE GEAR.

Method of Blocking Valve.

It is necessary to block the valve in central position covering the ports in case of a number of different breakdowns with the Walschaert valve gear. In some cases the valve stem crosshead is provided with a set screw which can be screwed tight against the valve stem crosshead guide, thus holding the valve immovable. If the engine is not so equipped, or if the breakage is such that the set screw cannot be used, the valve should be fastened in central position as described for Stephenson valve gear.

Broken Union Link, Crosshead Arm, Combination Lever, Valve, Valve Stem, Valve Stem Crosshead, or Valve Stem Crosshead Guide.

Disconnect the front end of the radius rod, and tie it or block it clear of the combination lever, also disconnect and tie up the union link, as shown in Figure J-2. Block the valve to cover the ports, as previously explained, and remove broken parts, and connections sufficiently so that they will not interfere with any moving or fixed parts. For high speeds the eccentric rod should also be removed. Now block the cylinder cocks open, make provision for lubrication of the cylinder, and you are ready to proceed.

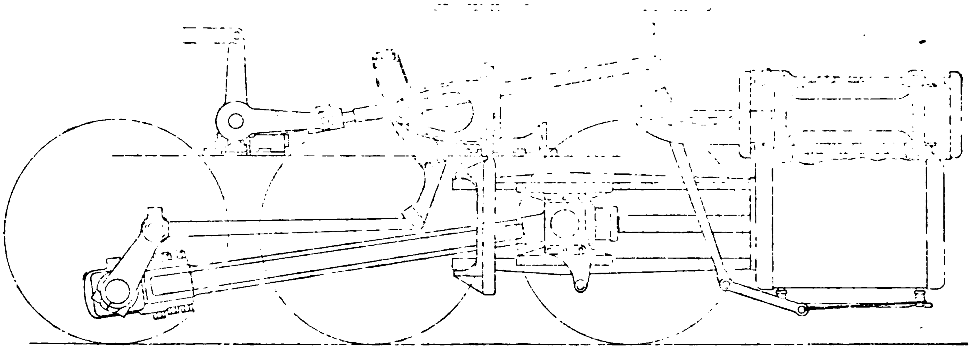


FIG. J2

Broken Front End of Radius Bar, Broken or Lost Front Radius Bar Bolt, Broken Front Cylinder Head, Piston or Piston Rod.

Proceed exactly the same as in the preceding paragraph, except that for slow speeds it is not necessary to disconnect the union link.

Radius Bar Broken at Link Block.

Remove radius bar and block the valve to cover the ports, block the cylinder cocks open, make provision for lubrication of cylinder, and proceed. For high speed, the union link should be disconnected and tied up as shown in Figure J-2.

Broken Eccentric Crank, Eccentric Rod, or Link.

Remove the eccentric rod, and if necessary remove the eccentric crank also. Disconnect the union link from the crosshead arm and tie union link to cylinder cock, block the valve to cover the ports, block the cylinder cocks open, make proper provision for the lubrication of the cylinder, and you are ready to proceed.

Broken Lift Shaft Arm, Radius Bar Lifter, or Radius Bar Lifter Guide.

Remove broken parts, as shown in Figure J-3 and proceed, working engine full stroke. For the style of valve gear illustrated, gravity will hold the link block in the bottom of the link, which is the position for forward motion. If it is necessary to back up, the link block must be blocked at the top of the link. If there is a considerable distance to go, and if the engineer considers it advisable, the link block may be blocked in the link at a point which will give a cut-off long enough to start the train, and take it over the ruling grade, instead of working full stroke.

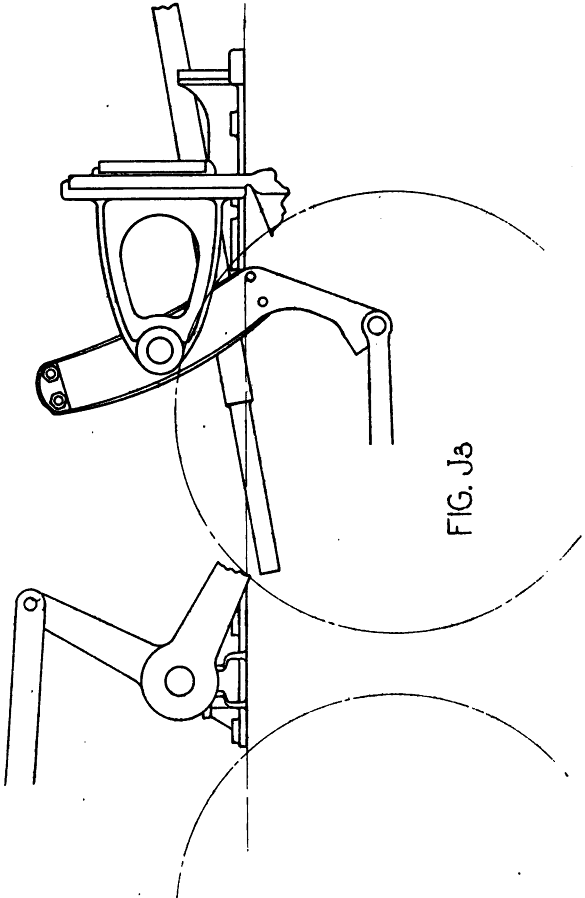


FIG. J3

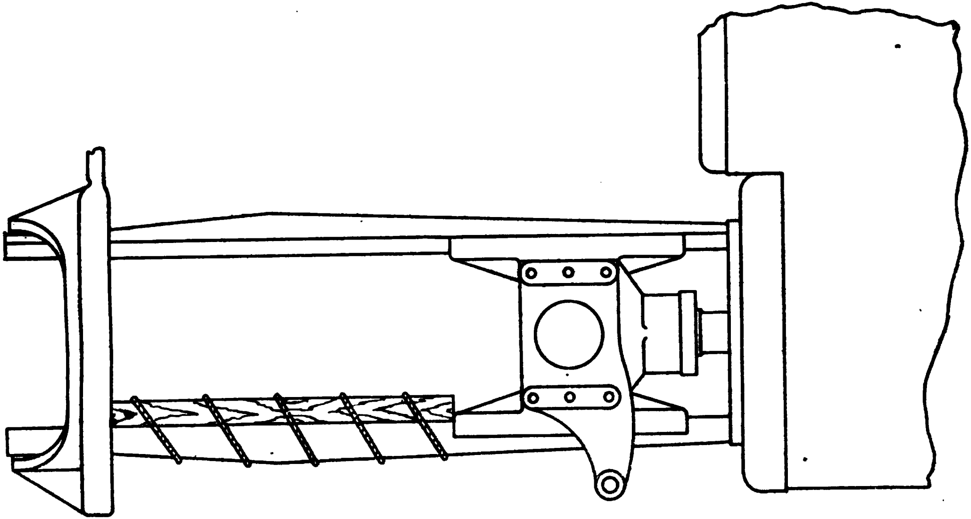


FIG. J4

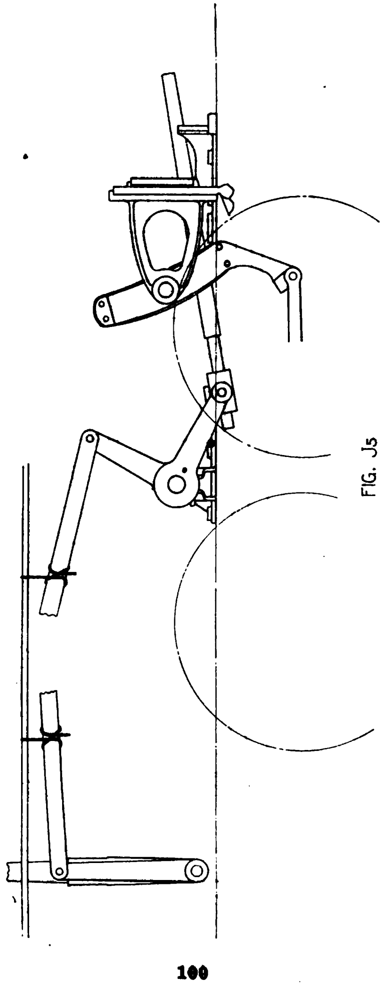


FIG. J5

Broken Main Crank Pin, Crosshead Pin, Main Rod, Crosshead, Guides, or Back Cylinder Head.

Remove eccentric rod and main rod; block the crosshead as shown in Figure J-4. Remove side rods if necessary. Block valve to cover ports, and you are ready to proceed.

Broken Reach Rod.

Tie up the reach rod as shown in Figure J-5. You can now proceed, working engine full stroke. For backing up, it would be necessary to block the link block at the top of the link. If the arrangement of the valve gear is such that gravity pulls the link block into position for backward motion, it would be necessary to block the link block at the top of the link for forward motion. If it is not desired to work the engine full stroke, the link block may be blocked in position to give the required length of cut-off, for forward or backward motion, as desired, so that the engine will start the train and take it over the ruling grade.

Both Link Trunnions Broken Off.

Remove eccentric rod, disconnect radius rod from combination lever, and tie the combination lever and link to the running board. Block the valve to cover the ports, as previously described. For high speed, disconnect the union link and tie it back to the cylinder cock, in which case it is not necessary to disconnect the radius bar. Now block the cylinder cocks open, make proper provision for the lubrication of the cylinder, and proceed.

BAKER VALVE GEAR.

Figure K-1 shows a modern type of Baker Valve gear with inside steam admission.

BROKEN PARTS WITH THE BAKER VALVE GEAR.

Method of Blocking Valve.

The same remarks apply as in the case of the Walschaert valve gear with regard to the manner of blocking the valve to cover the ports when necessary. The valve stem crosshead is provided with a set screw as shown in Figure K-2 for the purpose of holding the valve immovable.

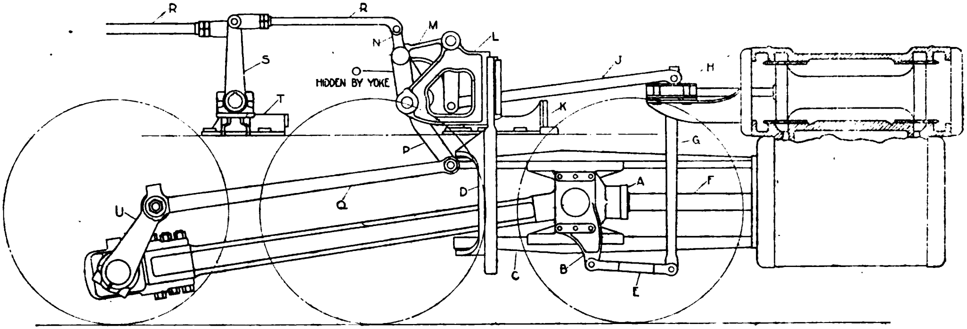


FIG K1 IMPROVED BAKER VALVE GEAR

NAMES OF PARTS			
A	CROSS HEAD	L	GEAR FRAME
B	CROSS HEAD ARM	M	BELL CRANK
C	GUIDE	N	REVERSE YOKE
D	GUIDE YOKE END	O	RADIUS BAR
E	UNION LINK	P	GEAR CONNECTING ROD
F	PISTON ROD	Q	ECCENTRIC ROD
G	COMBINATION LEVER	R	REACH ROD FRONT
H	VALVE STEM CROSSHEAD GUIDE	S	REVERSE SHAFT ARM
J	VALVE ROD	T	CROSSTIE AND REVERSE SHAFT SUPPORT
K	CROSSTIE AND GUIDE YOKE BRACKET	U	ECCENTRIC CRANK

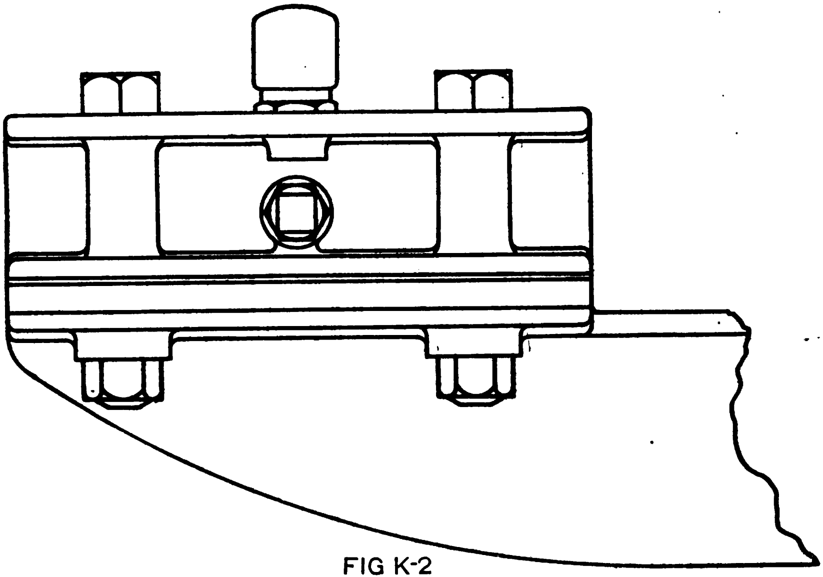


FIG K-2

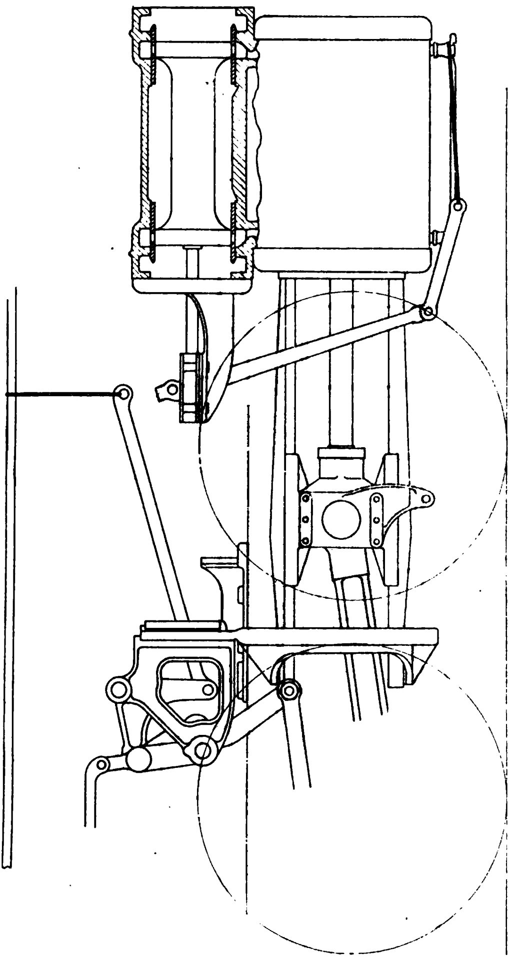


FIG K3

Broken Union Link, Crosshead Arm, Combination Lever, Valve, Valve Stem, Valve Stem Crosshead, or Valve Stem Crosshead Guide.

Disconnect front end of valve rod, tie or block it clear of combination lever, and disconnect and tie up the union link as shown in Figure K-3. Block the valve to cover the ports. Broken parts and connections should be removed sufficiently so that they will not interfere with any moving or fixed parts. For high speed the eccentric rod should also be removed.

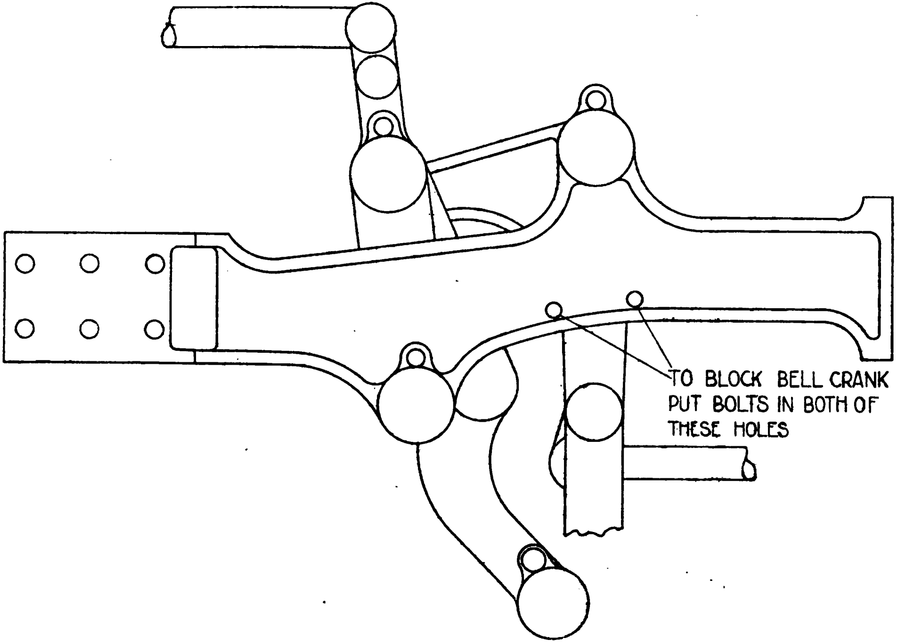
Broken Valve Rod, Vertical Arm of Bell Crank, Front Cylinder Head, Piston or Piston Rod.

Handle exactly the same as in the preceding paragraph, except that for slow speeds it is not necessary to disconnect the union link.

Broken Eccentric Rod, Eccentric Crank, Lower Part of Gear Connection Rod, Radius Bar, or Horizontal Arm of Bell Crank.

Some forms of the Baker gear are provided with holes in the gear frame so that the bell crank may be easily and securely blocked in position by means of bolts. See Figure K-4. In such cases, take down the broken parts and connections, so far as necessary, block the vertical arm of the bell crank, knock out back pin of short reach rod, and throw reverse yoke over against the frame, in forward motion. You are now ready to proceed. On the disabled side, the valve will get only the motion imparted by the crosshead through the union link and combination lever, that is, the valve will have lap and lead travel, and a port opening equal to the lead, for all cut-offs. This procedure has two advantages: (1) that some turning effort is realized on the disabled side, and (2) that the small movement of the valve on the disabled side will permit oil from the lubricator to reach the cylinder.

If the arrangement of the valve gear is such that the bell crank cannot be easily blocked in position, it will be necessary to proceed as follows: take down broken parts and connections so far as necessary, block valve in central position covering the ports, disconnect the union link and tie it to the cylinder cock, as shown in Figure K-5. Block the cylinder cocks open, make proper provision for lubrication of the cylinder, and you are ready to proceed.



TO BLOCK BELL CRANK PUT BOLTS IN BOTH OF THESE HOLES

FIG. K4

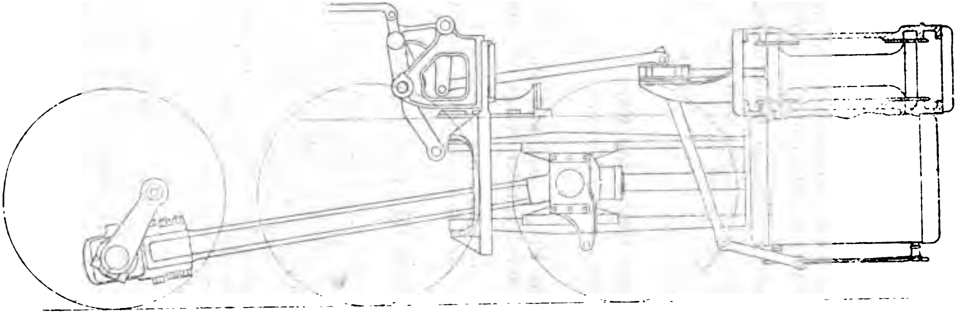


FIG K5

Broken Upper Part of Gear Connection Rod.

If the break is near the middle pin, handle the same as for a broken eccentric rod and also tie lower end of gear connection rod to keep it from swinging.

If break is near the top and below the jaw, block the bell crank, and wire the gear connection rod fast to the radius bars, and proceed same as for a broken eccentric rod.

Reverse Yoke Broken at Top, or Broken Reach Rod.

Block the yoke in running position using blocks of wood, front and back, and take down short reach rod. Of course, it will be necessary to change the blocking if it is necessary to run backward at any time.

Reverse Yoke Broken Below the Ears.

Take down eccentric rod and proceed as directed for broken eccentric rod.

Broken Main Crank Pin, Crosshead Pin, Main Rod, Crosshead, Guides, Back Cylinder Head, or Guides Thrown Off.

Remove eccentric rod and main rod and block the crosshead as described under same heading for Walschaert valve gear.

THE SLIDE VALVE.

Figure D-1 shows in sectional view the ordinary balanced slide valve with which we have all at some time been familiar. I would just mention that the port of opening in the valve casting marked with the letter "V" is the so-called Allen port, which has been used quite extensively, although it is not an essential and indispensable part of the slide valve proper. The various parts of the slide valve have been designated with reference to letters, and names of parts are shown in the table below the cut.

The writer does not intend to include here a treatise of the functions and theories of valve action, but has merely attempted to illustrate by the drawing and this brief explanation the parts (in their proper relation to one another) of the slide valve as ordinarily used.

The purpose of the Allen port in the valve is to increase the length of the steam port.

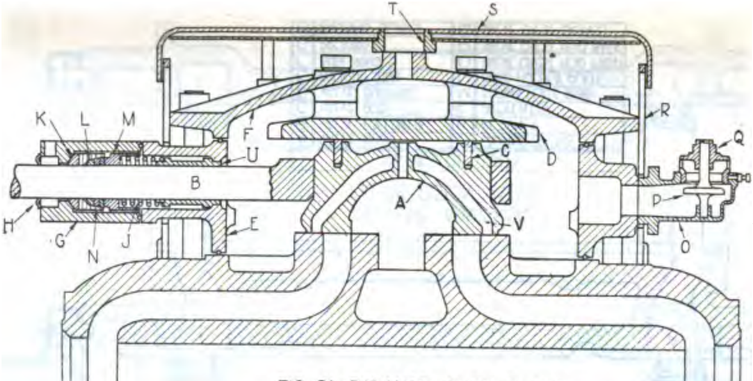
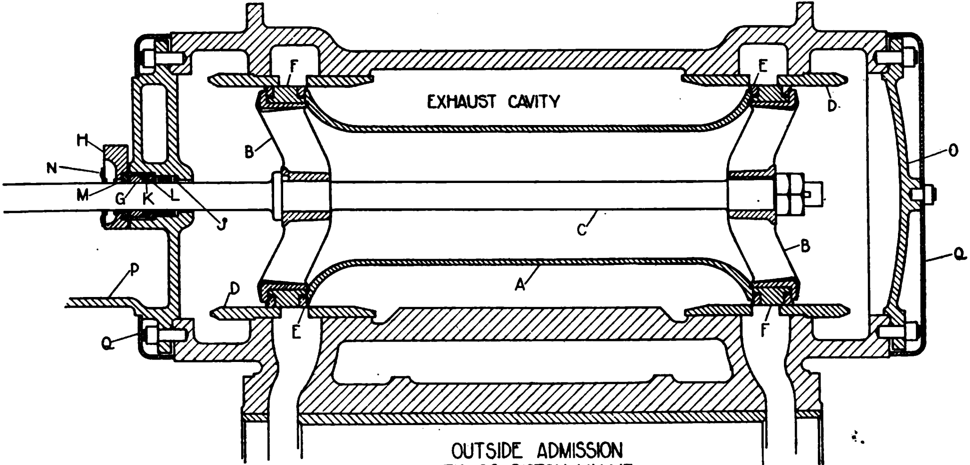


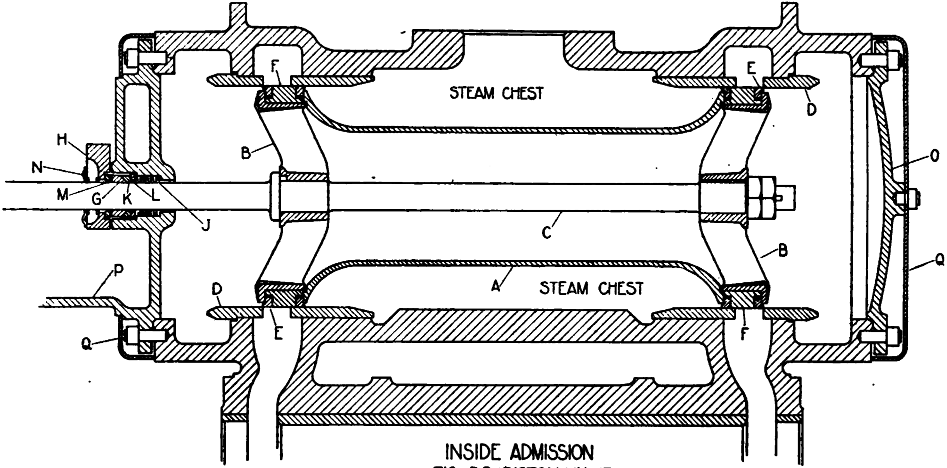
FIG. DI BALANCE SLIDE PLATE

NAMES OF PARTS			
A	VALVE	L	PACKING RINGS
B	VALVE ROD	M	PREVENTER
C	PACKING STRIP	N	VIBRATING CUP CASE
D	BALANCE PLATE	O	RELIEF VALVE BODY
E	STEAM CHEST	P	RELIEF VALVE
F	STEAM CHEST COVER	Q	RELIEF VALVE CAP
G	PACKING GLAND	R	STEAM CHEST CASING SIDE
H	SWAB HOLDER PLATE	S	STEAM CHEST CASING COVER
J	PACKING SPRING	T	STEAM CHEST CASING THIMBLE
K	JOINT RING	U	VALVE ROD SUPPORT
V	ALLEN PORT		



OUTSIDE ADMISSION
FIG D2 PISTON VALVE

NAMES OF PARTS			
A	VALVE BODY	J	PACKING SPRING
B	VALVE FOLLOWER	K	RETAINER
C	VALVE ROD	L	PREVENTER
D	VALVE BUSHING	M	SLIDING PLATE RING
E	PACKING RING	N	SWAB HOLDER PLATE
F	BULL RING	O	VALVE CHEST HEAD FRONT
G	PACKING	P	VALVE CHEST HEAD BACK
H	PACKING GLAND	Q	VALVE CHEST CASINGS



INSIDE ADMISSION
FIG. D3 PISTON VALVE

NAMES OF PARTS			
A	VALVE BODY	J	PACKING SPRING
B	VALVE FOLLOWER	K	RETAINER
C	VALVE ROD	L	PREVENTER
D	VALVE BUSHING	M	SLIDING PLATE RING
E	PACKING RING	N	SWAB HOLDER PLATE
F	BULL RING	O	VALVE CHEST HEAD FRONT
G	PACKING	P	VALVE CHEST HEAD BACK
H	PACKING GLAND	Q	VALVE CHEST CASING

THE PISTON VALVE.

The piston valve is now in general use on the majority of the roads in this country. It can be arranged to admit steam to the cylinders from cavities at the ends of the valve spool or from a cavity at the center, i. e., the space around the valve spool or valve body. When arranged as first mentioned it is called an outside admission valve, and when the last mentioned arrangement is used it is called an inside admission valve.

Figure D-2 shows the arrangement of parts for an outside admission valve, and Figure D-3 shows the arrangement ordinarily used for inside admission. Both methods are in quite common use, and it is very likely that along with the gradual trend toward the use of superheated steam the piston valve will come into universal favor.

SOUTHERN VALVE GEAR.

Figure L shows Southern valve gear, with list of parts. The manner of disconnecting on this gear is similar to that of the Walschaert gear, and should be readily understood from the sketch.

TO FIND THE PROPER LOCATION WHEN AN ECCENTRIC HAS SLIPPED.

The student should not try to find the position of the eccentric by finding the center. There are two simple ways of doing this; either of which can be done quickly if performed in the right manner.

Placing the engine near the center and setting the eccentric by turning it around until steam comes out of the cylinder cock nearest the piston, has always been our favorite plan. This method has its disadvantages, and on engines equipped with automatic lubricators it is a good plan to set the slipped eccentric by the one that has not slipped. A good plan is to place the crosshead within one-half inch of the end of its travel at the front end of guide, with the main pin above the center line. Then drop the lever into the forward notch, open the cylinder cocks, move the eccentric to approximately the condition indicated by the mark of the keys where they came in contact with the axles, which would be ordinarily between the second and third spokes. So continue to move the eccen-

NAMES OF PARTS			
1	MAIN ROD	13	REACH ROD END
2	MAIN ROD STRAP	14	AUXILIARY REACH ROD
3	ECCENTRIC ROD	15	MAIN REACH ROD
4	ECCENTRIC CRANK	16	REVERSE LEVER
5	CROSSHEAD	17	FRONT CYLINDER HEAD
6	CROSSHEAD WRIST PIN	18	BACK CYLINDER
7	PISTON ROD	19	FRONT STEAM CHEST COVER
8	VALVE STEM CROSSHEAD	20	BACK STEAM CHEST COVER
9	VALVE STEM	21	VALVE ROD
10	VALVE	22	TRANSMISSION YOKE
11	BELL CRANK	23	RADIUS HANGER
12	REVERSE SHAFT ARM	24	MAIN CRANK PIN
		25	LINK

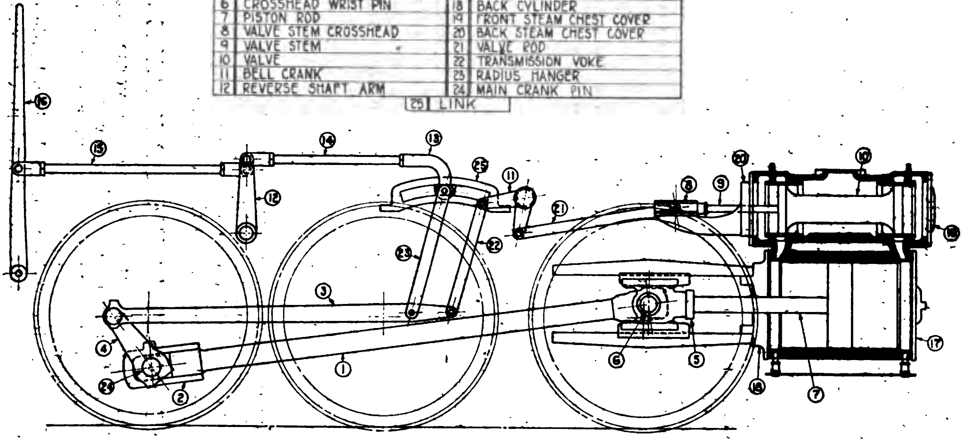


FIG. L SOUTHERN VALVE GEAR

tric until steam will just ooze out of the front cylinder cock. This can sometimes be accelerated by turning on the lubricator so that steam will ooze through to the steam chest and through the cylinder cock from the lubricator. The reason for placing the crosshead one-half inch short of the extreme travel is to avoid trying to find the center, and also to give the engine at full stroke a little lead.

Where it is not possible to get steam through the steam chest or lubricator, or similar method, without opening the throttle, it is desirable to use the following method: It it is the forward motion eccentric, place the engine on forward center as close as you can guess, put the lever in the back notch, make a mark on the valve stem flush with the gland or stuffing box, then put the lever in the forward notch; then get under the engine, after seeing that the slipped eccentric is opposite the good one, turn it ahead until the mark that you just made on the valve stem again comes flush with the gland or stuffing box, fasten it there and go along.

A little time spent by the engineer each trip befort starting out in trying the set screws and seeing that the eccentrics are properly oiled, will usually prevent this kind of failure, which should be the object of every engineman.

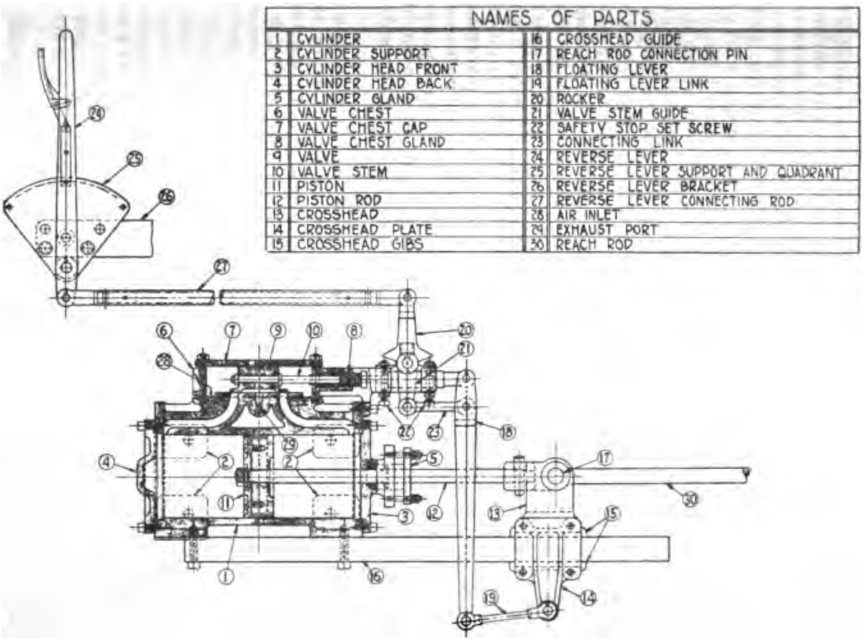
In such cases, report at the end of the trip what you have done, as eccentrics set on the road are not always near enough right to give a good valve motion. Besides, this will indicate to your Master Mechanic that you can make proper repairs and get your engine in all right. If you have made any errors in making the repairs, you will be better off by knowing it, and you will at least get credit for trying to do something. The Company will be bettered by the correction. "Time is money."

With the outside valve gears eccentrics rarely slip, though eccentric cranks sometimes break. These happenings are so rare that they would come under an entirely different class, and are treated elsewhere in this volume.

RAGONNET POWER REVERSE GEAR.

Figure G shows a patented power reverse gear, the invention of Mr. E. L. Ragonnet. This reverse gear has passed the experimental stage, is used on a number of modern locomotives, and is thoroughly practical.

The cylinder is located on the right hand side of the engine, usually under the running board and just forward of the fire-



NAMES OF PARTS			
1	CYLINDER	16	CROSSHEAD GUIDE
2	CYLINDER SUPPORT	17	REACH ROD CONNECTION PIN
3	CYLINDER HEAD FRONT	18	FLOATING LEVER
4	CYLINDER HEAD BACK	19	FLOATING LEVER LINK
5	CYLINDER GLAND	20	ROCKER
6	VALVE CHEST	21	VALVE STEM GUIDE
7	VALVE CHEST CAP	22	SAFETY STOP SET SCREW
8	VALVE CHEST GLAND	23	CONNECTING LINK
9	VALVE	24	REVERSE LEVER
10	VALVE STEM	25	REVERSE LEVER SUPPORT AND QUADRANT
11	PISTON	26	REVERSE LEVER BRACKET
12	PISTON ROD	27	REVERSE LEVER CONNECTING ROD
13	CROSSHEAD	28	AIR INLET
14	CROSSHEAD PLATE	29	EXHAUST PORT
15	CROSSHEAD GIBS	30	REACH ROD

FIG. G RAGONNET POWER REVERSE GEAR

box. The gear is preferably operated by air, although an auxiliary steam connection is provided. Air is admitted to and released from the cylinder by an ordinary "D" slide valve (9), arranged for outside admission. The piston rod is connected to a crosshead which is coupled to the reverse shaft by means of a suitable reach rod (30). The crosshead gibs are held in place by a cast steel plate (14), having an arm extended downward. This crosshead arm is connected by a suitable link with the lower end of a floating lever (18). The upper end of this floating lever is pivotally connected and supported by the valve stem, which in turn is carried by a cylindrical guide. Through the agency of a rocker (20), the upper end of which is connected by a light rod, with a small reverse lever (24), and the lower end through a link with the floating lever a short distance below the valve stem, the movement of the valve is controlled from the cab. This mechanism is so constructed that the valve is returned to central position on the ports when piston (11) occupies a position in the cylinder that corresponds to the same relative position of lever (24) with quadrant (25). The rocker above referred to is provided with tappets, which strike the ends of projecting set screws when the limit of travel of the valve is reached. These set screws require no adjustment after the gear is properly applied, and merely limit the throw of the reverse shaft arm in either direction. There are some others, but they are substantially the same in principle.

The small reverse lever (24) is locked in any desired position by an ordinary tooth quadrant. Assuming the lever in mid position and the valve normally covering both ports; when lever (24) is moved into forward gear (to the right, referring to the drawing), the floating lever (18) swings about this lower end as a fulcrum and the slide valve is moved to the right, admitting air to the left hand end of the cylinder. The piston now moves to the right, and the floating lever, pivoting about this intermediate or reverse lever connection, returns the valve to its central position, unless the progressive movement of the reverse lever is continued. Thus it will be seen that when the lever is shifted to any desired location, the piston moves in the proper direction until the valve gear reaches a corresponding point, whereupon the valve is automatically returned to its central, or lap, position.

Since the exhaust, or inside lap of the valve is materially greater than the outside lap (which is very small), air is held on both sides of the piston at the same time. It will thus be seen that the mechanism is prevented from creeping or vibrating by an elastic cushion formed by compressing the air in one end of the cylinder or the other. In no case does the valve open to exhaust when holding the gear in any desired cut-off position. Owing to this arrangement, the gear is very economical of air; in fact, when piston and piston rod packing are properly maintained, the loss of air when holding the valve gear in a fixed position is practically nil.

The cylinder is oiled through a small lubricator, conveniently placed in the cab, and suitable means of lubrication are provided on all moving parts.

The entire mechanism is simple in construction, and has proved very reliable in service. As a rule, no auxiliary hand gear of any description is applied or needed. This gear is very desirable on heavy power and for medium power where a great deal of short switching is performed.

HOW TO BLOCK FOR A BROKEN MAIN DRIVING BOX.

I recall my experience with a broken right main driving box on a heavy ten-wheeler. The box broke, both sides, just below the brass and the brass came down in the cellar. This engine was hung with short equalizers over the back and middle boxes, and a common "U" saddle over the front box, short spring, ends up, over front box, and a long heavy spring, ends down, between the back and middle boxes; a short equalizer between front and middle boxes, and the back end of front spring coupled to a short equalizer, this in turn to the equalizer over the middle box; the back end of the short equalizer over the middle box and front end of same over the back box, coupled to the long heavy spring between back and middle boxes, with the usual array of hangers.

This engine was put in shape to take to the shops, 103 miles, as follows: A wedge of oak, 3 ft. 5"x5", was made, and the wheel that had the broken box was run up onto it. This pushed the remainder of the broken box up to the top of the jaw. A liner was then put behind the wedge at the top, and the wedge driven up tight, forcing the top part of the box against the shoe and holding it securely between the wedge and shoe, so that it would not come down on the journal. The pedestal and brace were then taken out and the bottom part of the box and cellar removed. An oak block, 7 x 8, was then sawed off the end of a new tie just long enough to fit above the pedestal and brace between wedge and shoe. A recess, or notch, was cut in this block for the journal to run in. Two short pieces of iron were laid across the top of the pedestal brace under the block to prevent same from splitting. A bar of hard soap was placed in the notch—driving box grease will answer just as well to lubricate the journal. The front end of the back spring and the back end of the front equalizer were blocked up as high as possible, and then the wheel was run off the wedge. This took all the weight off the middle driving box and transferred it and the weight of the middle wheel, end of journal, eccentrics and rod connections, on the front and back boxes, which made a heavy load for the springs, but aside from the little "list" to that side, the engine went home all right, 25 miles per hour.

The object of carrying the main wheel off the rail was to throw some weight in the notch in the block below the journal, so that in a measure the block would steady the main axle when using steam. This same principle may be applied to any type of engine, making sure that the springs and equalizers are blocked in such a manner as to take the weight of the broken box off the journal, transferring it to the other wheels of the engine.

This method of blocking is shown in Figure "A," where the front and back boxes are blocked to clear the rail. Block No. 2 should be slightly grooved in the center, so as to accommodate the grease, and in the case of a broken driving box, block No. 1 would extend from the face of the wedge to the face of the shoe.

This same method of blocking may be used for a broken tire. The principal thing to remember is that in the case of a broken driving box, the end of the equalizer, or the spring front and back of the box, immediately should be blocked to the frame, and the weight should be carried by means of the blocks on the tie strap.

BROKEN DRIVING WHEEL TIRE.

If the broken tire is held with a retaining ring and the condition is such that the wheel can revolve with safety, proceed as follows: Run the wheel up on a wedge about five inches thick, then remove the oil cellar and fit a block in its place, and fill with another block all the space between the bottom of driving box and the pedestal brace. In order to take the weight off this journal, block up the front end of the equalizer nearest to, and on the same side as the wheel that has the broken tire. Then when you run this wheel off the wedge, the weight that should be on the journal of this wheel will be distributed between the truck and the other drivers. If the rods are not damaged, leave them all on and go along, keeping watch that nothing gives way to let the tire onto the rail.

If the rods are bent or otherwise damaged and it is a front or back wheel, it is sometimes possible to take off that section of the rod which drives the wheel that has the broken tire. In such cases, if the side rod is taken off on one side between two pairs of wheels, the corresponding side rod should also be taken off on the opposite side.

Figure A illustrates how this blocking should take place. If the tire is broken and has no retaining ring, and it is not possible to get the tire out from between the wheel and the guides, or some other obstruction, and it is necessary to leave the tire on the wheel, then the pair of wheels should be blocked clear of the rail, the wheels securely chained so they will not revolve, and the tire chained to the wheel. That section of the rod which rotates the pair of wheels that has the broken tire should also be removed. This will enable the engine to be brought home with safety.

With an eight-wheel engine, if the back tire breaks, run the wheel without a tire up on a wedge high enough so that block can be inserted between the top of front driving box and frame. Then take the oil cellar out of the box of the wheel with the broken tire, and fill all the space between the journal and pedestal brace with a solid blocking, as explained above. It is generally good policy to remove the side rods on both sides, so as to reduce the weight on the wheel, though this is not necessary. It is generally not necessary to take out the springs.

The engine is now blocked ready to take in, but it is necessary to keep the back wheel with the good tire on the rail. To do this, take a good chain, make one end fast around the tail beam under the cab on the engine, or around the back end of the locomotive frame at the same corner as the wheel without the tire; pass the other end through over the draw bar and make it fast to the opposite corner of the tank frame. Tighten this chain by driving a wooden wedge in the loop at each end. This is better than to attempt to carry both back wheels off the rail and putting a tee rail from the firebox into the tank in order to hold them up.

This is a more difficult case to handle than where a front tire is broken, as taking the weight off of the front tire means

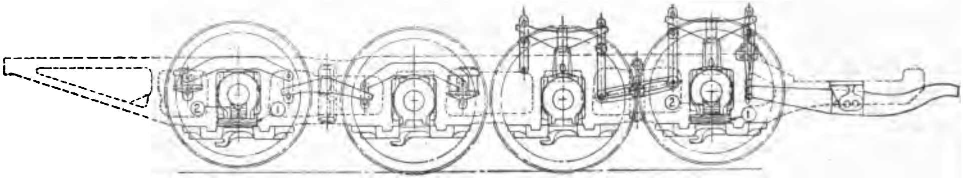


FIG. A

distributing it on the back pair of drivers and the engine truck, which is easily done. If both back wheels were raised clear of the rails the engine would be about evenly balanced on the front wheels, and it would then be necessary to support the back end from the tank.

Ten-wheel engines are often used with a blind tire on the main wheels. When the back tire on such engines breaks and the main drivers have blind flanges, you have only the flanges on the front driver and the back wheels to keep the engine on the rail. This may be provided for as follows: If the rods are not damaged, leave them on and run the tireless wheel up on a wedge high enough so the box will be up to the top of the jaw. Remove the oil cellar and block the journal, as described above. After this, block up the back end of the long spring with block as high as possible. When the wheel is up on the wedge the engine will be "listed" a little to the other side. This can be taken advantage of to secure the engine so she will not get off the track on curves or backing up. To do this, pass a heavy chain in a loop around the opposite front corner of the tender frame, and if necessary, bolt it securely to some of the parts so that it cannot slip. If it is a wooden beam or sill, spike it. Then pass the other end over the draw bar to the other side and attach it to the cab support, or "jacking beam," on the engine; make the chain tight by driving in a long wooden wedge. When you run the engine off the wedge, the chain will be tight and the flange on the opposite wheel will hug the rail. In rounding curves or backing up over frogs and switches, you should have one man watch the leading wheel, and run with a safe speed.

BROKEN MAIN PEDESTAL BOLT OR BINDER.

Modern engines are built with pedestal tie straps, though there are still a number of engines equipped with pedestal bolts that bolt on the main binder. Take out the bolt from the back jaw and put it in the main jaw in place of the broken bolt; then, if a temporary bolt can not be obtained for the back jaw, and the bolt is broken just under the head, rivet the old bolt over so as to form a temporary head, and hold it in place with one nut. This will take you to your destination.

BROKEN ENGINE TRUCK TIRE.

In this case it is not convenient to remove the wheels. The first thing to do is to jack up the front end of the engine, take out the engine truck cellar of the box nearest the broken tire, make a block to fit in this space, about the same as shown for the driving boxes. After the block is securely applied, raise that corner of the truck frame high enough so that the wheel having the broken tire is about five inches above the rail. Chain the corner of the engine truck to the main frame, so that the main frame of the engine will carry the weight of this corner of the engine truck and keep the truck wheel off the rail. The corner of the truck frame that is chained up should then be chained across to the main frame on the opposite side as a safeguard in going around curves; this on the same principle as chaining the ten-wheeler for the broken back driving tire. The four-wheeled truck will then be run on three wheels, but no high speed should be attempted.

In the case of a two-wheeled truck, this same practice may be resorted to, though it is sometimes good policy to raise both wheels off of the rail by blocking between the pedestal tie strap and the journal; jack up the front part of the engine and place blocks between the top rail of the frame and the top of the front driving boxes. This will transfer the weight of the front part of the engine onto the front driving wheels, instead of onto the engine truck.

SAVING TROUBLE AND DELAY.

A good way to help yourself out if you are a long way from the shop, and have a spring partially broken and liable to give out on the road, is to take a large nut or a good iron block and tie it securely with a wire under the end of the equalizer nearest the bad spring. Do not fill all the space between the end of equalizer and frame; leave room enough so that on ordinary track the equalizer will not rest on the nut, but close enough so that when an unusually rough spot in the track, such as a bad frog or a low joint, is run over, the jolt will come on the nut or block, and not on the weak spring.

If the spring is badly broken and the equalizer is down pretty well, it would then be good policy to wedge under the end of the equalizer securely. This will usually take you home. If the spring does give out, the end of your equalizer will be up, and all you need do is to use the wedge and put the block between the box and the frame.

BROKEN ENGINE TRUCK SPRING.

This generally results in the front end of the engine dropping too low and the pilot coming in contact with some obstruction. If the pilot can be taken off, or if it clears, run the engine in with the frames riding on top of the boxes.

If this cannot be done, use a small jack to raise the end of the truck frame high enough so as to put a block between the top of engine truck box and frame, front and back. If you cannot get a small jack, put a chain under the engine truck frame and over the front frames of the engine. Drive a wedge in securely to tighten the chain. Put a jack under the front beam and raise the engine. This will bring your engine truck frame up with it. Then block between the engine frame and the engine truck boxes. See that the broken spring is either taken out or securely fastened so that it will not fall from place, and proceed.

This is also true on a two-wheeled engine truck. These are usually equipped with coil springs. Where the spring is directly over the box, the broken parts of the spring serve as a block to hold the weight of the engine.

As stated before, if the pilot is high enough to clear, or if the pilot can be taken off, just see that the broken and loose parts are properly secured and take the engine in.

BREAKING CENTER PIN ON FORWARD END OF LONG EQUALIZER ON A TWO-WHEELED TRUCK.

With this form of accident, the front end of the equalizer usually drops onto the top of the engine truck axle. A very good method is to jack up the front end of the engine about level, then put another jack under the front of the equalizer that is down, and raise it up high enough so that you can chain it to the front deck casting or braces.

Another good way is to run a tie or rail across the front frames and chain the front end of the equalizer to this.

Still another way is to place a truck brass between the axle and the equalizer and let the equalizer down onto it. This gives you some weight on the forward truck, which is desirable, and by keeping the combination lubricated good, time can be made without any particular risk or danger.

BROKEN FRONT ENGINE TRUCK AXLE.

This does not often happen, but when it does it is a very awkward breakdown to handle. A good method is to jack up the front end of the engine and take out the broken parts. Then jack or pry up the truck frame, and chain the end of same to the main frame, the same as for the broken tire. If you have two chains, use them and fasten each side by itself. One long chain can be used, but in doing so, see that it is not tied in a loop across the front end. Chain each side separately so that if the chain should break at least one side will remain fastened. The chains may be further tightened by driving a wooden wedge, or wedging with iron between the chain and the top of the frame.

This same principle may be applied to the rear pair of axles, or it may be applied to a two-wheeled engine truck, bearing in mind that all of the load must be carried by the front end of the engine.

BROKEN MAIN AXLE.

A ten-wheeler broke the main axle on the left side, close up to the wheel. All the side rods were taken off, the broken end of the axle was jacked up, and a good block placed under the axle in place of the oil cellar. Then all the space between the block and the pedestal brace was filled with another good solid block, the main rod was taken down, valve rod disconnected and blocked centrally so as to cover the ports on the disabled side. The engine was then run in light, using steam only on a main wheel on the good side.

In case the break occurs on the inside of the journal bearings, we would proceed as follows: Pry or jack up the wheels on the broken axle as high as the boxes will allow. Use a bar and put in the largest blocks possible so that when the engine is let down, it will be high enough to carry the disabled wheels off the rail. Repeat this on the opposite side, and the engine is ready to be towed in. All rods and eccentric straps must be taken off. If the springs will not carry the engine high enough, it is a good plan to block between the top of driving boxes and frames.

BREAKING FRAME BETWEEN MAIN AXLE AND CYLINDERS.

When a main frame breaks between the main axle and the cylinder it is not good practice to use the engine, except to run in light. If an engine having a broken frame, as above stated, is worked to its full capacity in hauling a train, the broken frame will open and close at the break, putting a bending stress on the opposite frame, and if severe enough this stress will break that frame. In all such cases the proper thing to do is to disconnect the side of the engine having the broken frame and run in light.

BROKEN EQUALIZER OR BRACKET, OR BROKEN SPRING.

On engines equipped with equalizer post, this is usually bolted to the top rail of the frame. Where the bolts give way and let the engine clear down, the frames come on top of the boxes. The cotters should be taken out of the top ends of the extreme front and back spring hangers, run the back driving wheels on the wedge, and put a block between the top front driving box and the frame; then run the front wheel on the wedge, and block between the top of the back driving box and frame. If there is any likelihood of the springs or equalizer moving, take them out and place them on the tank, or chain them securely so they cannot move enough to do any harm.

Figure B shows the spring rigging of Pacific type engines; Figure C shows the spring rigging of Consolidated type. By reading carefully the instructions relative to blocking up for a broken driving box and blocking up for a broken tire, it will be more clear to the student just what he should do in case of a broken spring.

A spring or spring hanger will sometimes break and the parts will settle in such position that it is safe to continue on the journey. Sometimes the parts will interfere with the driving wheel or driving wheel spokes, and it is necessary to remove them. In such cases a block should be placed under the end of the equalizer affected by the broken spring, as shown in No. 15, Figure B, and No. 16, Figure C.

Where a two-wheel truck is used, as with the Consolidation engines, the front spring is usually connected by means of a

NAME OF PARTS			
1	DRIVER SPRING	8	SPRING HANGER
2	DRIVING BOX SADDLE	9	SPRING HANGER SEAT
3	EQUALIZER	10	SPRING HANGER BRACKET
4	EQUALIZER TRANSVERSE	11	SPRING HANGER PIN
5	EQUALIZER HANGER	12	SPRING HANGER GIB
6	EQUALIZER FULCRUM	13	SPRING GUIDE TRAILER
7	FRAME FILLING PIECE	14	TRAILING SPRING
15	WOOD BLOCK		

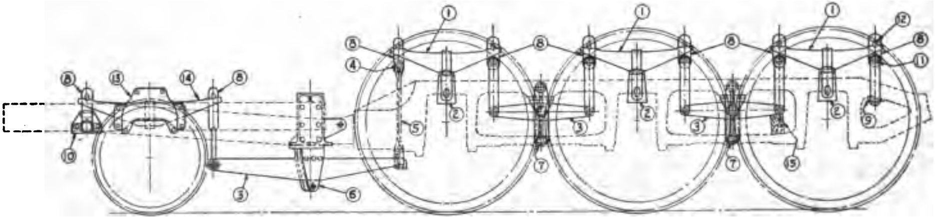


FIG B SPRING RIGGING PACIFIC TYPE

NAMES OF PARTS			
1	COIL SPRING	9	SPRING HANGER
2	DRIVER SPRING	10	SPRING HANGER LINK
3	DRIVING BOX SADDLE	11	SPRING HANGER GIB
4	EQUALIZER	12	SPRING HANGER PIN
5	EQUALIZER 3rd & 4th	13	TRANSVERSE EQUALIZER FRONT
6	EQUALIZER	14	TRANSVERSE EQUALIZER LINK
7	EQUALIZER FULCRUM	15	SPRING RIGGING SAFETY POST
8	FRAME FILLING PIECE	16	WOOD BLOCK

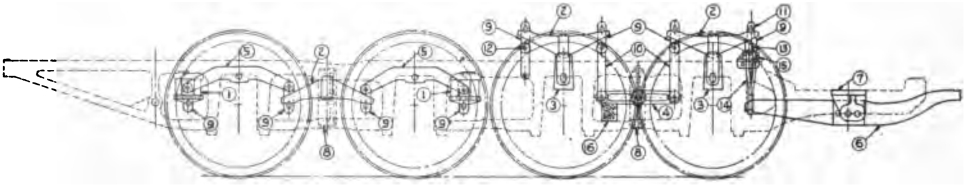


FIG. C SPRING RIGGING – CONSOLIDATION TYPE transverse equalizer No. 13, that extends across the frames, each end of the equalizer passing through the lower end of the front spring hangers, No. 9. A connecting link goes down from the center of this transverse equalizer and supports the back end of truck equalizer No. 6. It is customary on this design of engines to provide a spring rigging safety post on each side of the main frame, No. 15. In case the front spring breaks, the truck equalizer is prevented from dropping too far by the ends of the transverse equalizer (13) resting on the spring rigging safety posts (15). If the spring will clear the wheels, as stated before, proceed on the journey, though it is sometimes advisable to place a block between the front end of equalizer, No. 4, and the bottom rail of the frame.

It is a common occurrence to break a back driving spring or spring hanger on an eight-wheeled engine with springs above the boxes. For such a mishap you should have in your tender box a hardwood wedge, about 4"x4" and 3 ft. long. Place it on the rail and run the back driving wheel up onto it. Pry up the back end of the equalizer and block it as high as you can; then run the front driving wheel up on the wedge, and put a block between the top of the back driving box and the bottom of the frame. Pull down that driving box wedge a little, so if the box warms up it will not stick and cause you trouble. Run as fast as you can without getting the journal too hot. If, when the breakdown occurs, your lever is fastened, you may have to use jacks to raise the engine where they are available, but always use the wedge where you can.

When a front driving spring breaks, or a spring hanger, on an eight-wheeled engine with springs above the boxes, run the front wheel up on the wedge, block the front end of the equalizer, using your bar if possible to raise it, and if you see that the back spring will carry the engine all right, proceed. If not, run the back wheel on the wedge and put a block between the frame and top of front box. A good wedge in the tender for such emergencies is better than any kind of a jack, because it is quicker.

As stated in the first part of this article, however, there are times when a spring will break and the machinery is all clear, and it is possible to proceed to the terminal without doing any blocking.

THE SUPERHEATER.

This device, as is well known to all who have used it, when properly maintained and operated, effects the longest single step in advance ever made in the development of the locomotive. Figure K is all that will be necessary, when studied in connection with this article, to familiarize yourself with the device and its operation.

It will be noted that the steam when it leaves the throttle valve passes to the header (nigger-head), and thence back to a point near the firebox, then forward to the header and back the second time, and then forward and through the steam pipes into the steam chest. This process has the effect of drying the moisture out of the steam (superheating it), imparting to it (the steam) much higher temperature, and consequently increasing the efficiency of the engine,

At first some little difficulty was experienced in lubricating the valves, valve chest and cylinders, but this has disappeared almost entirely, the best help in this line being the action of the engineer in not entirely shutting off steam until the train is nearly to a stand. The little steam admitted in this way serves as all the lubricant necessary to drift the engine any distance desired. Of course, the usual amount of oil should be fed through the lubricator when drifting in this manner.

Most careful tests made in the past years by several important railroads demonstrate, beyond doubt, that a decrease of 25% to 30% in fuel consumption, in any service, is accomplished by the use of a properly designed and well-maintained superheater in the locomotive of the present day.

However, there are a few points that must be borne in mind by the engine crew, otherwise the good results from the superheater will not be forthcoming. The most important of all being the matter of carrying the water at a consistent level in the boiler. I have heard the remark made by engineers that "the superheater certainly cuts out the trouble they used to have through foaming with the saturated steam engines." This is true, but the price paid for the relief in that respect may be summed up as follows: The foaming in the boiler has not been "cut out," though the engineer does not notice it as he did on the saturated engine by water appearing in the cylinders and coming out of the smoke stack. What really happens when the boiler of a superheated engine is foaming is as follows: The water and scum passes out of the boiler, just as it did in the case of the saturated engine, but in

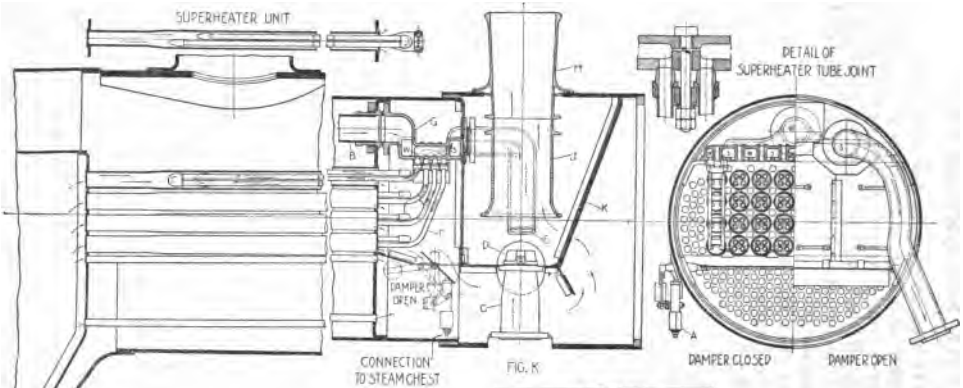


FIG. K

NAMES OF PARTS			
A	DAMPER	F	SUPERHEATER UNITS
B	DRY PIPE	G	SUPERHEATER HEADER
C	EXHAUST PIPE	H	SMOKE STACK
D	EXHAUST NOZZLE	J	SMOKE STACK EXTENSION
E	STEAM PIPES	K	SPARK ARRESTER

its passage with the steam, through the superheater units, it is evaporated and no water will reach the cylinders; but this very act of using the superheater units as a means of evaporating this water will entirely absorb the superheating capacity of the units and defeat the economy in fuel consumption that the superheater ought to produce, and besides, the solids that are deposited in the superheater units are dried there and blown into the steam chests and cylinders, destroying the lubrication and very seriously lessening the efficiency of the engine, and, most of all, so far as the crew are concerned, making their labor, especially that of the fireman, about 30% greater than it should be.

Watch for foaming just as you did with the saturated engine, and keep the water level in the boiler down as low as consistent with good service; in other words, two gauges are always plenty. And if you keep these things in mind you will surely reap benefits in bounteous proportion to your efforts. Keep the water glass and gauge cocks in good condition. Use both every trip, and check one against the other, and then keep the water in the boiler down to two gauges, and you will win.

THE SMOKE BOX OR FRONT END.

Figure K shows a modern smoke box arrangement, and represents the arrangement now standard on most American railroads. The parts are indicated by reference to letters, which are fully explained in the table.

SMOKE BOX DRAFT.

Front end drafting appliances are some of the very important things that should be thoroughly understood by engineers and firemen alike, for on these depend much of the comfort of both men.

Some of the indications of wrong conditions in the front end may be summed up as follows: If the exhaust pipe base joint is leaking it will cause the fire to clinker badly on the front of the grates, and, usually, causes the lower flues to leak. If the exhaust passes up one side of the stack, or alternately one side to the other, you are likely to have a hard steaming engine, and one that will fail easily. In order to have the best possible conditions for steam-making, the exhaust steam jet should not touch the sides or any part of the smoke stack or draft pipe; it should pass up through the center and thus allow its whole circumference to entrain and carry out the gases from the front end. Any scraping or impinging of the steam jet on any part of the stack or draft pipes lessens its (the steam jet's) capacity as an entraining agency—result, hard steaming engine. Report what you observe at the end of the trip.

LEAKY EXHAUST PIPE JOINTS.

A leaky joint between the exhaust nozzle and the pipe, or between the exhaust pipe and saddle, no matter how slight it may be, is sure to do two very noticeable things: First, it will make the engine a poor steamer; second, it will cause the flues to leak, especially in the lower rows.

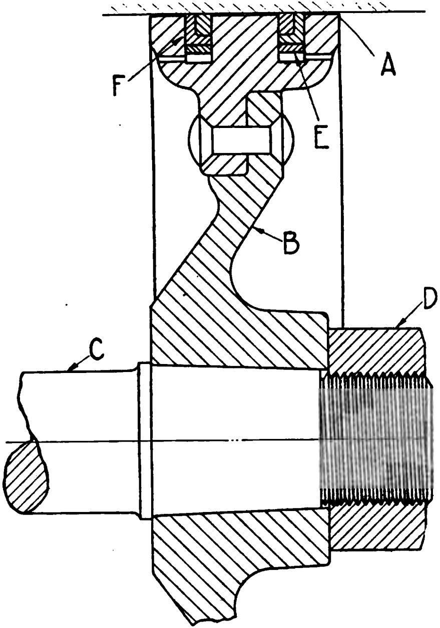
The modern engine is usually provided with four heavy bolts to hold the exhaust nozzle onto the pipe or base. The base is provided with from six to eight heavy studs to hold it down on the saddle. It is our experience that the joint between the exhaust nozzle and the pipe or base should be a ground joint. Face both joints to a face plate, and grind them together so as to make a steam tight joint. Then bolt them uniformly and securely.

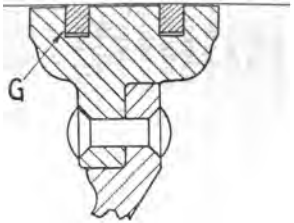
For the bottom joint of an exhaust pipe we know of no better plan than that outlined for the fitting of the nozzle to the exhaust pipe proper.

DISTINGUISHING BLOWS IN VALVE AND CYLINDER PACKING.

This is a subject that should be carefully studied by the young engineer, as a careful analysis of steam blows in the steam chest and cylinder, and a proper reporting of same, will save a great deal of work in the roundhouse. Many engineers get confused in making their reports on this particular defect, and the result is four or five hours' extra work in the roundhouse to locate the trouble.

Years of experience and study have "fixed" the ear of the old veteran so that he can distinguish by sound and hit the thing about right nearly every time, but even they are sometimes deceived. We are unable to picture the sound to the reader that would indicate beyond a doubt whether the blow is from the valves or the cylinder packing. With the smaller type of engines where a gasket was used on the front cylinder head, it used to be practical to take off the front cylinder head and try the engine by admitting steam into the back end of





	NAMES OF PARTS
A	BULL RING
B	PISTON HEAD
C	PISTON ROD
D	PISTON ROD NUT
E	PACKING SPRING-DUNBAR TYPE
F	PACKING RING-DUNBAR TYPE
G	PACKING RING-SNAP TYPE

FIG. 61

the cylinder to see if the steam would blow through the piston packing.

With the modern engine, this is sometimes quite a task. Placing the valve central on the seat is not a reliable means of determining whether or not a valve blows, as sometimes a badly cut valve ring or valve seat will make a joint so that the blow will not be noticeable. If you are running an engine with balanced valves and a blow is suddenly developed, accompanied by a more or less jerky action of the reverse lever, it is fair to conclude that a balance strip spring is broken, allowing the strip to drop and letting steam chest pressure onto the entire top of the valve, thus destroying the balance of same. In this case the blow would be uniform, as all the steam that is making it comes down through the half-inch hole in the top of the valve in the exhaust port.

Where cylinder packing is blowing, place the crank on quarter, and with the reverse lever in ahead and the cylinder cocks closed, apply the driver brake; then open the throttle. If the cylinder packing is defective there will be a strong steam blow out through the stack. Then slowly pull the reverse lever up toward the center, which will move the valve back to central position, covering steam port and preventing steam going from the steam chest into the cylinder. If it is cylinder packing blowing, as soon as the valve is on the center the blow will stop. This, in our opinion, is a very satisfactory way of testing cylinder packing blows.

Another method is to open the cocks, and if steam blows out through the back cylinder cock when the front of the cylinder is full of steam, it indicates defective cylinder packing. This method, however, is not as reliable, in our opinion, as the former.

A broken live steam valve ring will usually result in a heavy exhaust on the side where the valve ring is broken. A broken exhaust ring will usually result in a light, scattered exhaust on the side where the valve ring is broken.

A careful study of this feature by young engineers will mean a large amount of money saved for the company that he is working for.

Figure G-1 shows piston head and cylinder packing.

WHAT A SLIPPED ECCENTRIC MAY DO ON LINK MOTION ENGINE OR ANY OUTSIDE GEAR.

The question is often asked, "Why are cylinder heads sometimes blown out and crosshead or spider keys sheared on account of eccentrics slipping?" This question can be answered more clearly by following the movements of an engine equipped with a common "D" slide valve, or an engine equipped with the piston type of valve. This condition is not as likely to happen on an engine with the balanced form of slide valve.

The knocking out of cylinder heads, shearing of spider or crosshead keys on link motion engines usually occurs in service while steam is being used. The cause tor same is that after one end of the cylinder has been filled with steam, the eccentric getting out of order allows the valve to cover the port that has just filled with steam and remain in that position; then with the steam chest pressure on top of the slide valve and the piston comes forward the compression of the steam so imprisoned runs up so high that it will blow out a front cylinder head if the steam happens to be on the front end of the cylinder, or if on the back end of the cylinder, it will either blow out the head, shear the crosshead or spider key, or perhaps damage all three. With piston valves the results are just the same.

With a balanced slide valve such damage is not as likely to happen as would be the case with an unbalanced slide valve or a piston valve, for the reason that with a balanced slide valve we have but a small area of the top of the valve exposed to the pressure in the steam chest, and hence the increased pressure caused by the piston approaching the end of the cylinder will in some instances raise the valve off its seat and relieve that end of the cylinder. This cannot happen with the piston valve, for obvious reasons, and is very unlikely to happen with the ordinary "D" form of slide valve without balance.

With the outside valve gears, such as the Walschaert, Baker-Pilliod, or Southern, there is less liability of steam being trapped in the cylinder than with a link motion gear, but should anything happen to any of these gears which would stop the valve from performing its regular travel functions the same results will be forthcoming.

DAMAGE IN SLOW MOVEMENTS WITH WATER IN CYLINDERS.

Ordinarily outside valve gears, such as the Walschaert, Baker-Pilliod and Southern, cause very much less trouble than does the link motion, for the reason that with any of the above mentioned gears there is lead enough so that at the time the piston comes about to the end of its stroke the valve opens sufficiently to allow the steam or water which is being compressed in front of the piston to be squeezed back into the steam chest.

With the link motion engine, which is set line and line with full stroke, that is, without any lead, it frequently occurs that the steam port does not open in time and cylinder heads are broken, crosshead keys, spider keys, etc., sheared. Ninety-nine per cent of this trouble at least is started in moving engines after they have been standing still for some time, and especially in the winter time.

HOW THE INJECTOR WORKS.

It is as follows: Consult Figure E. A jet of steam is admitted through the steam nozzle A, to the combining tube B, and condensing nozzle C, and the water that has been brought to the injector by priming, condenses this jet; the steam passes through the steam nozzle at a very high velocity, and when the water condenses it, its velocity is imparted to the water, and the water and condensed steam pass from the combining and condensing nozzles to the delivery nozzle D. The impact or blow of the stream exerts against the under side (or injector side) of the boiler check valve, a pressure sufficient to overcome the boiler pressure acting against the upper side (or boiler side), the result being that the water lifts the check valve and enters the boiler.

You see then that the action of the injector is the result of the high velocity with which the jet of steam strikes the water entering the combining tube, transferring to it its momentum and forming with it a continuous jet having sufficient velocity to overcome the pressure of the boiler.

IMPORTANT THINGS FOR ENGINEER TO LOOK OUT FOR.

See to it that all valves are kept tight and spindles well packed. If not attended to, they will get worse.

Strainers should be kept clean. If not, they restrict the amount of water that can get to the injector.

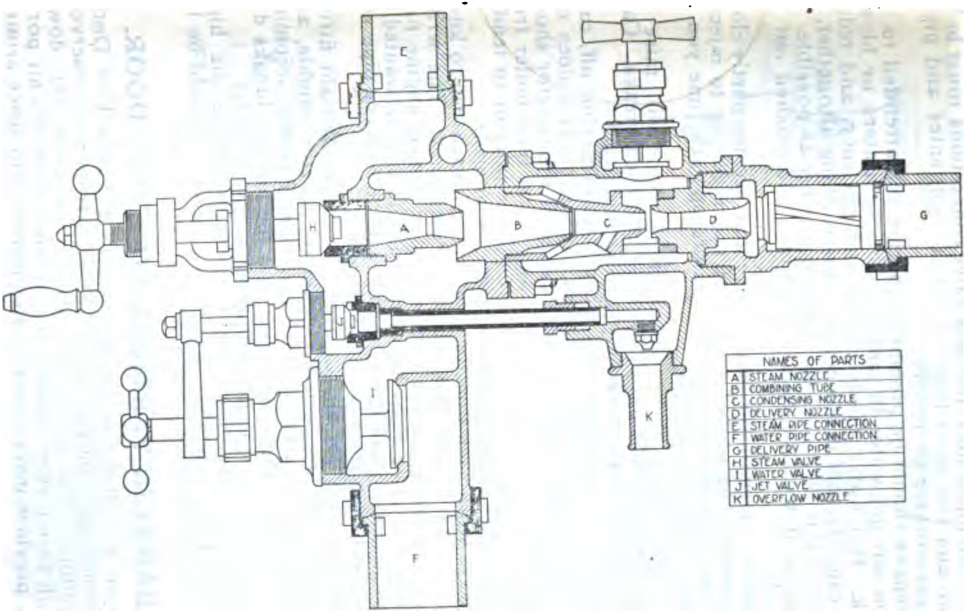


FIG E THE LIFTING INJECTOR

Suction pipes, hose and tank valve connections must be kept tight, and free from leaks; if not, air will enter and prevent proper working of injector.

Repairs should be promptly reported and attended to.

Do not get water in tank too hot, by heaters or blowing back. Hot water affects the lift and efficiency, and reduces the capacity, and if too hot prevents working altogether. In cases of this kind get cold water as quickly as possible.

See to it that the tender is cleaned and washed out frequently.

Due to oversight, the tender valve may become partly closed and prevent the proper amount of water getting to injector. Get the habit of checking this feature up each time you get engine out of roundhouse.

If boiler check sticks closed, the injector will raise the water, but throws it out at overflow and then breaks. Carefully tapping check valve on top will often help.

If boiler check sticks open when injector is shut off, carefully tapping valve will often seat the valve. If it does not, then the overflow and the water valves of the injector should be shut off to prevent the water and steam from boiler from going out of the overflow and through the injector to tender. Use the other injector until repairs can be made.

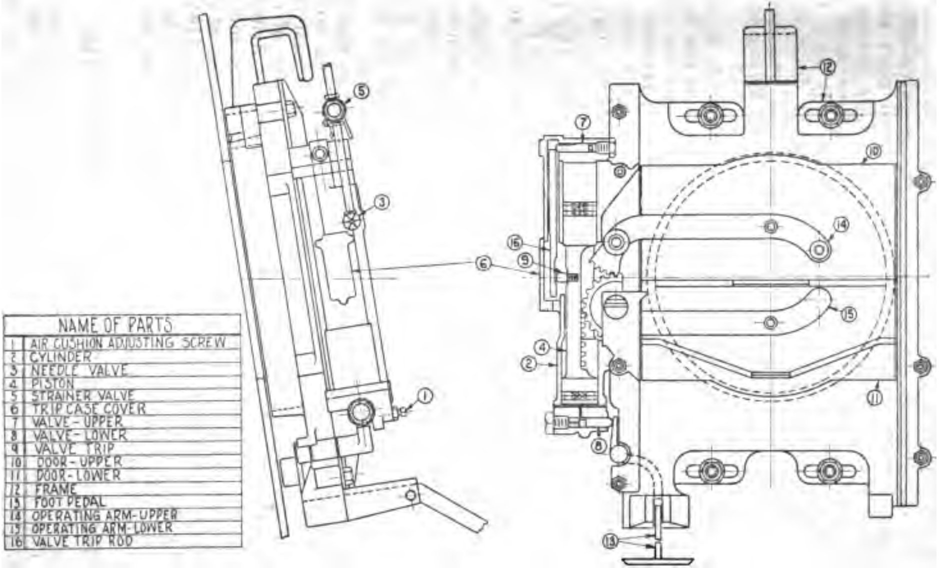
Always work each injector often enough each trip to know that you can depend upon them in emergency. The writer knows of cases when the engineer on a regular engine neglected to work the right injector until one day he wanted to in an emergency, and it was found that the delivery pipe was full of mud from the injector to the check.

It is necessary for air to enter the tender. A tight fitting manhole cover has been the cause of injector trouble, and there have been cases in winter weather of covers becoming frozen air tight, the result being that the injector breaks due to its not being able to get the proper supply of water.

Lifting injectors should be located just above the high water level of the tender. Non-lifting injectors should be located below the lowest water level of the tender.

FRANKLIN VERTICAL LIFT FIRE DOOR.

Figure F-1 shows patent vertical lift Franklin Fire Door. The broken pipe above strainer (5) leads from main reservoir connection. The air passes through strainer (5) down through needle valve (3) and at that point leads into air ports which provides main reservoir air pressure into space around



NAME OF PARTS	
1	AIR CUSHION ADJUSTING SCREW
2	CYLINDER
3	NEEDLE VALVE
4	PISTON
5	STRAINER VALVE
6	TRIP CASE COVER
7	VALVE - UPPER
8	VALVE - LOWER
9	VALVE TRIP
10	DOOR - UPPER
11	DOOR - LOWER
12	FRAME
13	FOOT PEDAL
14	OPERATING ARM-UPPER
15	OPERATING ARM-LOWER
16	VALVE TRIP ROD

FIG. F1 FRANKLIN VERTICAL LIFT FIRE DOOR

lower valve (8) Foot pedal (13) is so located that the fireman with his natural swing in delivering the coal to the firebox, places his left foot on the pedal. This opens valve (8), admitting air into the cylinder through the small port shown and against the lower head of piston (4). This forces the piston upwards. The rack on piston (4) engages with segments on upper and lower operating arms (14) and (15), which in turn engage with the upper and lower door leaves (10) and (11). This movement raises door (10) and lowers door (11), permitting the fireman with the same swing to deliver the coal into the firebox.

Piston (4) on its upward movement carries with it valve trip (9), which engages with valve trip rod (16) at the upper shoulder. This in turn moves upper valve (7) to the right, admitting air into the top of cylinder (2), which returns piston (4) to the lower part of the cylinder, closing the doors.

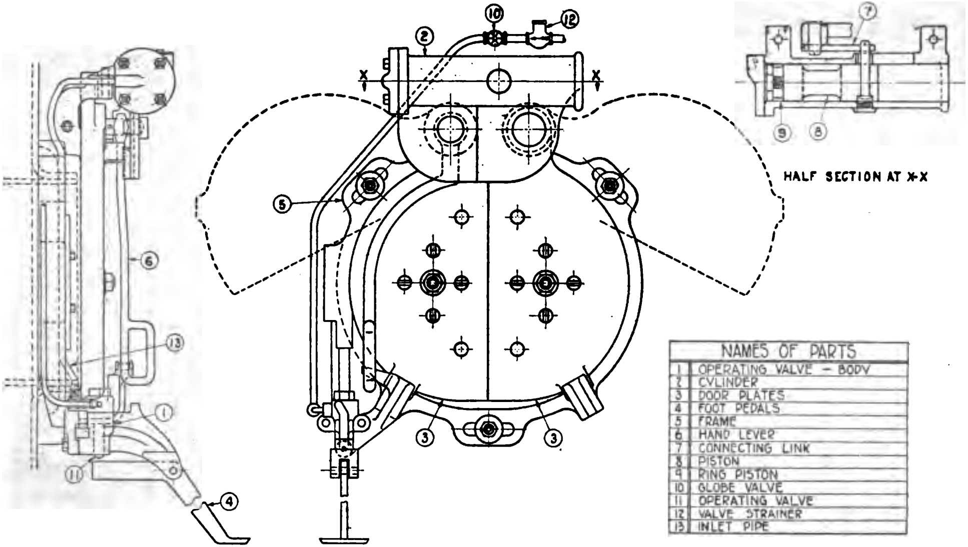
The air cylinder adjusting screw No. 1 is used to regulate the speed with which the door opens and closes. The principle is that the end of the adjusting screw restricts the flow of air through the port when leading into cylinder No. 2. The speed of the door may be accelerated by feeding the screw outward and retarded by feeding it inward.

This type of door, like the one shown in Figure F-2, have many advantages over the swing door. It permits the fireman to deliver coal into the firebox with two movements; namely, filling the scoop and delivering the coal, the door being opened, as stated above, by placing the left foot on the pedal with the natural swing of the body in delivering coal.

The door is safe in the event of a flue bursting in the firebox, as the positive pressure would close the door and hold it there unless the frame is forced off of the studs which hold it in place to the boiler head. It reduces the amount of cold air that is fed into the firebox during the process of firing to a minimum, and automatically regulates the one-scoop method of firing, as it automatically closes after each scoopful of coal is delivered. A handle is provided on operating arm (14) by which the door may be opened or closed when the air is not turned on. Air cushion adjusting screw No. 1 can be so adjusted that the door will not slam when closing.

FRANKLIN BUTTERFLY FIRE DOOR.

Figure F-2 is a patented fire door of the Franklin Butterfly type. This has the same advantages as the vertical lifting type of door, and an additional advantage claimed for it is



HALF SECTION AT X-X

NAMES OF PARTS	
1	OPERATING VALVE – BODY
2	CYLINDER
3	DOOR PLATES
4	FOOT PEDALS
5	FRAME
6	HAND LEVER
7	CONNECTING LINK
8	PISTON
9	RING PISTON
10	GLOBE VALVE
11	OPERATING VALVE
12	VALVE STRAINER
13	INLET PIPE

FIG F2 FRANKLIN BUTTERFLY DOOR

that it is not so liable to slam when closing as the vertical lift door. It is so designed that when the door plates have opened the proper distance, the connecting link is on a dead center with the piston, connecting link and door bolt. This arrangement stops the door without the least jar or slam.

The door is operated by air, which is admitted through globe valve (10), strainer valve (12), down to operating valve (1). The operator, with a natural swing in delivering coal, places his foot on pedal (4), valve (1) is raised from its seat, allowing air pressure to pass to the left end of the cylinder, the piston (8) is carried forward by this pressure and transmits this movement to the door through link (7), which is attached to the left hand door plate. The two plates are connected by two intermeshing gear teeth. As the piston moves forward, the door plates are caused to rotate around the fulcrum pin until they have uncovered the opening in the door frame, as indicated in dotted lines, at which time the connecting link is straightened out and the link connection on the left hand door is in a direct line with the center of the door and the connection on the piston. This arrangement provides a gradual stopping of the piston and door without hammer blows. When the operator removes his foot from lever (4), valve (1) will seat. This cuts off the admission of air to the cylinder and permits the air that is in the cylinder to exhaust. The weight of the doors will then close automatically, bringing the piston back to its normal position in the cylinder when the doors are closed.

A hand lever (6) is provided to operate the doors when there is no air pressure. A latch is provided, which has two notches to engage the hand lever. The first notch holds the door open about eight inches at the bottom. This allows the admission of air to the firebox while the locomotive is standing at stations. The other notch is located to hold the door in full open position.

The leaves or plates of the door are of hollow construction, providing the free circulation of air within them, admitting heated air to the firebox to aid combustion. A removable baffle plate is provided to facilitate the repairs. Care should be taken to see that arrow on strainer valve (12) points toward the globe valve (10). The pipe leading to main pressure reservoir should be screwed into the end of the strainer valve, as indicated by the broken section. There is a cap or plug provided on the top of this strainer valve for cleaning and refilling the strainer with mattress hair.

BRICK ARCHES.

There are three distinct types of brick arches for locomotive fireboxes. The first and oldest is the stud supported type, which is rapidly giving way to the second or tube supported type, and is now used only in certain narrow and medium width fireboxes, where the use of arch tubes is not considered practicable. In the second type the arch brick is supported by arch tubes running from the throat sheet to the back sheet of the firebox. In the third type the arch tubes are installed in the same manner as in the second type; the arch proper, however, does not go forward to the throat sheet, but is supported a short distance back by a refractory wall, forming a combustion chamber between the refractory wall and the flue sheet. The stud supported type consists of two rows of brick resting on lugs secured to the side sheets by studs, the inner ends resting against each other, and forming an arch practically self-supporting.

The third type of brick arch can seldom be satisfactorily applied to existing locomotive boilers, but in fireboxes especially designed to receive it the results are very satisfactory. It is known as the Gaines Locomotive Furnace, and is a combination of the Gaines Combustion Chamber and the Security Arch. The Gaines Combustion Chamber consists essentially of a fire brick bridge wall across the firebox, forming a combustion chamber between wall and flue sheet, the tubes being shortened and the firebox lengthened sufficiently to admit this application, while the grate area remains normal. The bridge wall is carried on a casting extending across the firebox and secured to the mud-ring at each side. This casting also supports the grate frames and the metal upright stays which prevent the wall from toppling. The floor of the combustion chamber is made of cast or wrought iron plates, protected with fire brick to prevent burning out, and, in order to care for cinder accumulation in the combustion space, a spark hopper is provided in the center, the floor being given a sufficient pitch to cause all accumulation to drop out when the hopper is opened.

The bridge wall is built up of special fire brick of such size as can be easily handled; in these bricks air passages are cored matching the openings in the carrier casting. The size and number of the air ducts vary according to the factors which determine the amount of air needed above the fuel bed.

The Security Arch used with this construction is supported on arch tubes, the number depending on the width of the firebox. These tubes extend between the firebox door sheet and the throat sheet or combustion chamber, and pass through the top brick of the bridge wall at such a height as to support the adjacent arch brick even with the top of the bridge wall; otherwise the construction is identical with the second type previously described.

The flame travel is greatly increased by use of the brick arch, resulting in a better mixing of the combustible gases and air, thereby securing more complete combustion. This results in a saving in fuel for equal rates of work, or an increase in capacity for the same amount of coal, the possible increase in capacity being above 10%.

The whole firebox heating surface is made effective as the flames are directed to the back head of the boiler and the crown sheet.

Cold blasts of air are prevented from striking the flues, either from a hole in the fire or when the fire door is opened. This eliminates shrinkage strains on the flues, resulting in reducing the chance for leaks from this cause.

The brick arch reduces by about 33% the quantity of black smoke emitted by the locomotive. This is due to more perfect combustion of the fuel, resulting in a decrease of free carbon in the gases leaving the smoke-stack.

These advantages are obtained by all types of brick arches; the use of arch tubes and sectional arch brick, however, has certain advantages not found in the stud supported type. The arch tubes provide a larger firebox heating surface and produce better circulation of the water.

CARE OF TENDER TRUCK JOURNALS.

The tender truck journal, when removed or when placed on the storage track, should be coated with a good heavy material that will prevent rusting. This coating should be thoroughly cleaned off of the journal before same is put in service. If emery paper or emery cloth has been used on the journal, it should be thoroughly cleaned off with oil before putting it in service. Journal bearings should be smooth and free from bruises. Journal boxes should be thoroughly cleaned out, removing dirt and sand. Dust guards should be applied in all cases when renewing wheels.

Engine truck and tender journals are running nearly 100% of the time with full loads. For this reason, the lubrication should be given close attention. It is desirable to use woolen waste. When new, this waste should be carefully pulled apart, and all foreign substances that may injure journals should be removed, and about four pints of oil should be applied for each one pound of dry waste. It is good practice to soak the new waste for twenty-four or thirty-six hours in warm oil, then allow the waste to stand on a screen or draining pan and let it drain until it contains about the above proportion of oil. In using old sponging, the waste should be carefully picked apart, and particles of brass, lead, and other foreign substances, shaken out, the sponging that is to be used should be thoroughly washed in warm oil by repeated plunging in and out of the oil by means of a suitable iron hook. This process washes out all of the dirt and water, and restores the original elasticity of the waste.

On passenger engines it is good practice to care for engine truck journals and trailer and tender truck journals at one point, if possible, allowing the engine to make a round trip. On modern heavy engines it is desirable, however, to examine the boxes at each terminal, stir up the waste with a spoon so as to bring it close to the journal. If there is evidence of water in the sponging, or indications of heating, the brass should be removed and examined, the journal examined, and if necessary, the box repacked. If the brass shows the least sign of fracture, or if there is a crack in the lining, it should be replaced with a new brass.

It is considered good practice to take out the engine truck cellar and turn the sponging upside down every two or three hundred miles. This brings the oily fibres close to the journal. Care should be taken in restoring the cellar to know that the sponging is not too tight, and that it is sure to come in contact with the journal. Care should also be taken to have the cellar a reasonably tight fit in the box, so that it will not vibrate and cause the sponging to settle away from the journal.

Engine trucks on fast freight engines should be examined before leaving the terminal and should receive practically the same care as passenger engines. On slow freight engines, it is not necessary to stir up the sponging as often as on passenger or fast freight. It is good practice, however, to examine the engine truck sponging every two or three round trips—more often, if necessary. Tender trucks should be examined at least every washout, being careful to note the condition of the sponging and also the condition of the journal bearings.

ADJUSTMENT OF THE DRIVING BOX WEDGES.

The first thing to be seen to is that the pedestal or thimble bolts are drawn up tight. Then place the engine on the top forward eighth on the right side, after which (if the wedges are behind the boxes) put a good block in front of the truck wheel, put the lever "in ahead," and give engine a little steam. (Never do the job when engine is cold.) The steam thus admitted will go in behind both pistons, which will pull the driving boxes ahead against the shoes, leaving the wedges loose.

Then take a bar about four feet long, and beginning with the main wedges set them up in pairs. Loosen up the wedge bolts, and pry them up as high as they will go, after which (on a ten-wheeler, mogul or consolidation) they should be pulled down as follows:

Main wedges, 1/16 of an inch.
Front wedges, 1/8 of an inch.
Back wedges, 3/16 of an inch.

On the eight-wheel engine:

Main wedges, 1/16 of an inch.
Back wedges, 1/8 of an inch.

This is based on wedges having taper of 1/16 inch to the inch; if wedges have but 1/32 inch taper to the inch, the amount of "pull down" as given above should be doubled, while if they are 1/8 inch taper to the inch it should be cut in two. The value of setting up wedges in this way lies in the fact that they are set up evenly, and the "pull down" is sufficient to insure ample "working room."

Always bear in mind that with your four-foot bar you cannot spread the jaws, and that when your whole weight is on it, you have only taken up the lost motion. This is why it is necessary to have a rule for the pull down, as some wedges might be binding a little, and if pulled down they seemed free, in all probability they would be lower than when you started the job.

CARE AND ADJUSTMENT OF ROD BRASSES.

When the engine comes from the shop, the brasses are usually bored larger than the pins. They are also bored so as to have a certain amount of lateral between the collar and the outside washer. The amount of this lateral will vary on different sized engines.

The brass on the tip end of main rod is usually filed open and is adjusted by means of the key wedge so as to keep it a snug fit on the crosshead pin. The back end main rod brass is fitted from a sixty-fourth to a thirty-second larger than the pin, according to the type of engine. It is also fitted so that it has a given amount of lateral sideways. The side rod brasses are bored from a thirty-second to a sixteenth larger than the pins, with about a sixteenth of an inch lateral. The pins are always supposed to be round and true in diameter.

The engineer, on the trial trip, should give his rod brasses very close attention, see that they are properly greased or oiled, see that the adjusting keys, the nuts and fastenings are properly secured, and examine them as often as possible to be sure that they are not running hot. Close attention the first twenty miles will usually result in a nice set of rod brasses. After they have made a few hundred miles, the pins will have worn down to a smooth, glassy bearing, and the brasses also. At this time the pins and brasses will be running cool. The keys at this time, and the brasses that are adjustable, can be set down tight so as to hold the brasses solid against the faces. This will bring the two sections of the brass firmly together.

After the brasses are broken in, the small engine will have about a thirty-second difference between the diameter of the pin and the bore of the brass at the back end of main rod.

On the larger engines, this will be about three sixty-fourths. This is just about right, and unless the pin gets very hot, the key should not be slacked off as long as the rod can be moved freely on the pin. If the brass becomes too large for the pin it will pound very heavily, and this pounding effect will heat the brass and heat the pin. This is especially so of heavy main rod connections.

After the engine is running all right, if there is the least tendency to pound, the set screws should be slacked and the keys driven down firmly until the brasses have worn enough to warrant taking them down for closing. Some skilled engineers are able to take care of their rod brasses almost indefinitely without having them filed.

EXAMINATION OF WATER GLASS AND GAUGE COCKS.

Water glasses and gauge cocks are something that the engineer and fireman cannot afford to overlook or neglect, as upon the proper working of both depends their personal safety and the protection of the lives and property of others.

These devices should be blown out by the engineer (and the fireman, too, if he is not present when the engineer is doing it) before the engine is taken from the engine house or terminal track, and a careful examination of all parts made to detect anything, such as leakages of connections, evidence of restricted openings in the cocks, or anything that would affect the working of either in any way.

To blow a water glass out properly, first close the bottom cock and open the blow-off cock, then open the bottom cock and close the top cock, then open both top and bottom cocks, leaving the blow-off cock open during all of these operations, and for a few seconds after both cocks have been opened.

Always take the benefit of the doubt by opening the top cock a little more than the bottom one, but don't fail to open the bottom one enough.

Don't be misled by the fact that the water bobs up and down freely in the glass; it will do that when the glass may be registering five or six inches more water than is really in the boiler. The only SURE way to KNOW the correct water level is by the means of the GAUGE COCKS.

SCIENCE OF HANDLING REVERSE LEVER.

I presume that this may seem, to some readers at least, nonsensical, as almost any engineer will think that "what he doesn't know" about that particular feature of locomotive handling "is not worth knowing." It is a fact, nevertheless, that there is a great field for improvement along that line.

The reverse lever and quadrant (since the passing of the "hook motion") has been intended for a purpose, and if they were intended only for the purpose of reversing and cutting the engine "out of gear," so to speak, there would only have been three notches in the quadrant, one at each end and one in the center.

The real purpose of the modern quadrant is to furnish a means whereby the locomotive can be made to perform its work to the best possible advantage, under all or any circumstances.

The writer has noted the practices of a great many men in handling this instrument of either waste or economy, and where one is found who seems to get all there is in the thing, out of it, another may not be handling it to any such degree of proficiency, and yet both men are in every other sense of the word, so far as success is concerned, first-class.

In freight service there are many who stall on the hill, on account of not possessing those very necessary faculties, confidence and good judgment, and either begin to climb the hill too long before they get to it, or do not begin early enough, and try to climb it all at once. The latter are the fellows who stall oftenest. Then there are others who approach the hill all right, but when the speed begins to decrease a little, they "drop her down" four to six notches at a drop. Those gentlemen like noise, and are willing to "double" occasionally for the sake of having it.

There is another fellow, who, to use a common expression, is afraid he will "knock her all to pieces." This fellow, it is safe to say, knows how to use the lever, and it is "good betting" that he will get to the top of the "knob" the first time he tries, oftener than any of the other classes.

Years of observation on passenger trains has led me to conclude that it is not the man who makes "fly stops," nor the fellow that "hits" them the hardest out of stations, that makes the best time; on the contrary, it is he who figures on taking everything out of the engine that can be taken and still maintain proper water level and steam pressure. If a man pulls out of a station with the throttle wide open and the lever in full stroke, until the fire is torn to pieces and the water is down lower than the proper level, it is a sure thing that he is going to have more trouble to make time than a good runner would have on the same engine. A "good runner," when he pulls out to make good time, thinks a lot of things all at once; he figures that a good boiler full of water will be an advantage, he figures to get "out of town" in such shape that a good boiler full of water can be carried. He figures that after the town is left behind he must run fast, he figures that that can be done easier if he has a full boiler pressure. He also figures to make up the time on the possible twenty-five or thirty miles between towns, rather than on the first mile after leaving any of them. This same individual also knows if an engine is working at 12-inch cut-off and is hooked from there to 6-inch, that one of two things is true—the engine was left at 12-inch cut-off too long, or was hooked up to 6-inch cut-off too soon, either of which conditions, the fellow who figures, will avoid.

Nearly all of the modern power is now equipped with a quadrant that makes it possible for the runner to vary the cut-off of his engine one-half inch at a time; this condition was brought about largely through the efforts of the man who figures, and he uses the improved device so as to get the good of it. When he pulls out, the lever is hooked back one notch at a time; he does this "by ear," as it were, not by landmarks. The man who "knows all about" that kind of thing, and varies the cut-off five or six notches at a time when going up a hill, is not usually the man who gets up the hill with his train in one piece.

The man who starts out on a passenger train and does not "figure" is not the man who has a record for making good time.

The "science" of handling the lever should be studied by all enginemen; there is lots in it, and knowing first how to handle it to the best possible advantage is one of the things that makes locomotive running easy, and efficiency sure.

SOUNDING THE HIGHWAY CROSSING SIGNAL.

The highway crossing signal is one that should be properly and distinctly given, and no fancy or half-given signals substituted. The automobile traffic is here to stay, and will increase in volume as time goes on, and the liability of crossing accidents will increase in proportion.

Do the best you can at all times and keep your conscience clear.

POOLING OF FREIGHT LOCOMOTIVES.

This is one feature of modern railroad operation that has its drawbacks as well as its admirable features. The only reason why any railroad ever pooled its locomotives is that they might get more service out of them; and it is, perhaps, needless to say that when pooled locomotives are properly cared for, there is nothing that will afford as much flexibility in the handling of the business to be done, and the consistent running of the engine crews in the matter of proper rest and regularity of service, as will the pool.

However, the engineers' side of the case and their responsibilities to the company must not be lost sight of, as for instance, if enginemen do not properly report defects of all kinds, and there are many that only enginemen can properly report, it is hard to maintain engines up to their highest efficiency. I have in mind, particularly now, the reporting of blows in the piston or valve packing, pounding in boxes, valves out of square, and many other items which enginemen will realize as fully as any one, can only be intelligently reported by the crew who bring the engine in.

It pays to **know**, and when one does **know**, it is easier to do right than otherwise.

THE ART OF BRAKING ON PASSENGER TRAINS.

A great many rules have been laid down by different authorities for the guidance of the engineer in this important branch of the work, but it is a fact that we have failed to see anything that is in accord with our own views. We, therefore, beg your kind indulgence while we tell you how we think braking should be done on passenger trains.

We everlastingly condemn the "parachute-drop" style of braking as being worse even than "dragging-in," and the man who practices it will never get a reputation as a "smooth" man with a train, nor will we admit that he will show any better record for time made, than will the other fellow who does not "drop" a few feet past the mark or water spout, as the case may be, every time he makes a stop.

Our idea of how braking should be done is as follows: Begin far enough back so you will not have to put the brake full on; make the initial reduction of not more than 5 to 8 lbs. and, before making any further reduction, give train chance to bunch. The stop should be completed with not more than a total reduction of 25 lbs., and less if possible. With long trains the two-application method should be followed. Remember that the final application should be as light as possible so as to avoid picking up wheels.

Ten out of every twelve water stops that are attempted in the "drop" fashion, result in a "stop-short" or a "run-by" unless the direct application port in the engineer's valve is resorted to. This, especially in the case of an experienced engineer, is, in the eye of the average traveler, a sign of incompetence or extreme carelessness, neither of which is an enviable reputation to bear. This style of braking, with those who make "drops," is not confined to water stops either; they often resort to the direct application port in making the regular station stops. Come into stopping places with a little reserve power, then if you see you are not going to stop soon enough, use it.

CARE OF THE AIR PUMP.

This is one of the parts of locomotive equipment that does not get fair treatment at the hands of the men to whom it is most valuable, the engineer.

Of course, there are conditions, especially in freight service, that makes it "hot" for the pump, but those evils can be greatly minimized by an engineer who is willing to and will give the pump its proper proportion of his attention. The two greatest evils to which the pump is subjected are, running it too fast, and oiling it too lavishly. The desire to pump up long freight trains in a minute, so to speak, is probably the most frequent cause, or excuse, for overrunning the pump, and when it heats up from such treatment, that is, when the heavy oiling is done, with a view to cooling it off;

which, however, has the opposite effect in nearly every instance. The evil in running the pump too fast lies in the fact that beyond sixty cycles per minute, the capacity of the pump is diminished rather than increased, because at any greater rapidity of action the indrawing end of the pump does not have time to fill, the result of which is that the air piston, in coming back, does so practically unresisted for a part of the stroke, and then in finally coming in contact with the little air that is there, it strikes a hard blow, with the result that some of the air that should be forced into the main reservoir, blows past the packing in the piston into the other end of the cylinder, and the friction that is produced at this time is what starts the pump to heat. If the pump is not run to exceed sixty cycles per minute, the indrawing end of the pump will have time to fill, and the piston, on the return stroke, will compress this air slowly enough, so that all air in front of it will have time to pass out through the discharge valve into the main reservoir and the blow past the packing rings, with its consequent friction, does not take place and the pump will not heat. In the matter of oiling the pump, would say, for the steam end, two drops every four minutes is ample, and for the air end, about one teaspoonful every ten hours is all that should be used. This should always be introduced through the cup provided for that purpose. Where the air cylinder lubricator is used, a more practical and effective means is secured in proper lubrication of the air cylinder of the pump. This device consists of three parts; sight feed fitting, emergency throttle valve and the check valve connection. The sight feed attachment is to regulate the amount of oil to the pump; the emergency throttle valve is used to throttle the pressure from the lubricator to sight feed valve, and to cut off the oil completely when not in use; and the check valve connection is connected directly to the air cylinder of the pump, and consists of a ball check seating upward, which prevents the compressed air from entering the oil pipe. This lubricator is connected to the oil reservoir of the main lubricator, at one end, and the air cylinder of the pump at the other, to operate the lubricator. First, the emergency throttle should be opened about on-half turn and then closed; then the sight feed valve opened a sufficient length of time to permit from three to five drops of oil to pass to the pump; then closed. This lubricator must not be treated as a lubricator for continuous feeding, but must be employed rather as a valve for use only when it becomes necessary to feed a few drops of oil to the pump. In pumps where the air is compounded, the low pressure air cylinder will not require oiling as often as with the high pressure cylinder. When pump is properly lubricated and run at the proper speed, trouble while on the road will be avoided. Air pumps very often run pretty warm for the first few davs after being bored out, which must be expected, as the walls of the cylinders and new packing rings are a little rough at first, but if given proper treatment for a few days will become smooth and tight, and the heating will cease. Care and good judgment in oiling the air end results in easy handling engineer's valve and a good working feed valve.

FEED VALVE TROUBLES.

It frequently occurs that after a valve has been in regular service and in proper adjustment for several months, that it will begin to lose control of the brake pipe pressure, i. e., the brake pipe pressure will run up too high, sometimes up to that of the main reservoir. The remedy usually applied in such cases, and always without the desired results, is to slack off on regulating nut, thus taking the tension off the spring in the feed valve. This is wrong. A little thought on this subject will make it plain that while the spring may get weaker, it will never get any stronger while in service.

In such cases the trouble can usually be located in the feed valve itself and is usually due to a dirty condition. Whenever feed valve begins to lose control as referred to, just empty the brake pipe, remove the cap nut, take out the supply valve and piston, and clean with oil. At the same time, see that the seat upon which it rests is free from gum or anything that will prevent the supply valve making an air tight joint.

When the pressures are carried all right on train, but with a light engine will equalize, that is evidence that there is a slight leak in the feed valve, not enough to overcome the leakage in the train, but too much for that of a light engine.

STICKY TRIPLE VALVE.

There are times when this kind of thing is annoying, especially if you are slowing down and do not wish to stop. They are found oftener on tender brakes than elsewhere, and this is due to the fact that tender brake triples are used as much as the driver brake triple, and very much more than those on cars, and yet get the least attention of any. Usually, if they look all right on the outside when the engine is undergoing repairs, they are just painted over and let go. The result is, that any time, with that kind of attention the ring and the piston become so badly worn that it does not make a good enough joint on the walls of the triple body, and the air, instead of moving the piston, blows past into the auxiliary reservoir and the brake sticks.

Another cause for triple valve sticking may be due to the slow rise of brake pipe pressure when making a release of the brakes, and this is more apt to happen where the triple valve is in a dirty condition and triple piston packing ring worn.

BRAKE PIPE LEAKAGE ON FREIGHT TRAINS.

This, to our mind, is the greatest menace to the safe and proper handling of freight trains in existence, because in many instances, trainmen in order to avoid trouble, operate only a portion of the brakes on the train, notwithstanding the orders to the contrary.

Then again, it is almost impossible for an engineer, be he ever so skillful, to do proper braking, especially in descending grades, because if he makes a sufficient reduction to insure his brakes going on, with a view to steadying his train on a hill, it is ten to one that he will, in order to avoid stopping altogether, have to release at the very time that such a course is inadvisable, and to some extent dangerous, because it may be at a point, on a curve, for instance, where signals, although close ahead, cannot be seen.

It is generally found that freight equipment is not kept in as good order as passenger equipment, but the reason for the greatest percentage of the trouble lies with the parties owning private lines of cars.

Trainmen and enginemen are, to a great extent, responsible for the bad condition of the equipment, inasmuch as they, almost universally, neglect to carry out their instructions relative to reporting faulty and defective equipment as laid down in the rules of their company, instead of which they resort to making hose joints with paper, tying up leaks in the pipe with a string, etc. All this is wrong, and until the time comes when the superintendents get the information that they are entitled to through their trainmen and enginemen, the air brake service on freight trains will not be as it should. Leaky gaskets in hose coupling, split pipes, pipes worn through by contact with some part of the car body, porous hose and de-

SHOWING:-

1. LEAKAGE OF AIR FROM TRAIN BRAKE PIPE WITH A 3-4-5-6-7 LBS. PER MINUTE PRESSURE DROP ON 50, 60, 70, 80, 90, 100 CAR TRAINS WITH 70 LBS. BRAKE PIPE PRESSURE.
2. TIME REQUIRED WITH DIFFERENT AIR PUMPS TO RESTORE BRAKE PIPE PRESSURE TO 70 LBS. WITH 3-4-5-6-7 LBS. PER MINUTE PRESSURE DROP.
3. PER CENT OF AIR FURNISHED BY THE DIFFERENT PUMPS THAT IS AVAILABLE IN THE BRAKE PIPE WHEN RESTORING BRAKE PIPE PRESSURE TO 70 LBS. WITH LEAKAGE DROP OF 3-4-5-6-7 LBS. PER MINUTE.

DIFFERENT LENGTH TRAINS ASSUMED TO HAVE ONE HALF 8 INCH AND ONE HALF 10 INCH EQUIPMENT.

MAKE AND CAPACITY OF AIR PUMP	BRAKE PIPE LEAKAGE IN LBS PER MIN. PRESSURE DROP	50 CAR TRAIN			60 CAR TRAIN			70 CAR TRAIN		
		VOL. FREE AIR IN BRAKE PIPE AT 70 LBS. PRESS = 392.19 CU FT			VOL. FREE AIR IN BRAKE PIPE AT 70 LBS = 470.6 CU. FT.			VOL. FREE AIR IN BRAKE PIPE AT 70 LBS = 550 CU. FT.		
		LEAKAGE IN CU. FT. FREE AIR PER MINUTE	MINUTES TO PUMP BACK AIR LOST BY PRESS. DROP	PER CENT OF AIR FROM PUMP AVAILABLE IN BRAKE PIPE	LEAKAGE IN CU. FT. FREE AIR PER MINUTE	MINUTES TO PUMP BACK AIR LOST BY PRESS. DROP	PER CENT OF PUMP AIR AVAILABLE IN BRAKE PIPE	LEAKAGE IN CU. FT. FREE AIR PER MINUTE	MINUTES TO PUMP BACK AIR LOST BY PRESS. DROP	PER CENT OF PUMP AIR AVAILABLE IN BRAKE PIPE
WESTINGHOUSE 9½" CAPACITY = 33.1 CU. FT OF FREE AIR PER MINUTE	3	17.8	1.46	46.2	21.3	1.80	55.7	24.9	2.90	17.9
	4	22.9	2.25	30.8	27.5	4.91	16.9	32.1	32.1	2.11
	5	28.2	5.75	15.0	33.9	BEYOND PUMP CAPC'TY		39.5	BEYOND PUMP CAPC'TY	
	6	34.2	BEYOND PUMP CAPC'TY		41.1	"	"	47.9	"	"
	7	38.8	"	"	46.6	"	"	54.4	"	"
WESTINGHOUSE 11" CAPACITY = 47.5 CU. FT OF FREE AIR PER MINUTE	3	17.8	.60	62.5	21.3	.81	55.2	24.9	1.07	48.2
	4	22.9	.85	51.7	27.5	1.37	42.2	32.1	2.00	32.4
	5	28.2	1.46	40.6	33.9	2.49	28.6	39.5	4.94	16.8
	6	34.2	2.57	28.0	41.1	6.42	18.5	47.9	BEYOND PUMP CAP'CT	
	7	38.8	4.50	18.1	46.6	51.7	1.89	54.4	"	"
WESTINGHOUSE 8½" COMPOUND CAPACITY = 85 CU. FT OF FREE AIR PER MINUTE	3	17.8	.26	70.2	21.3	.33	75.0	24.9	.41	70.1
	4	22.9	.36	73.1	27.5	.46	67.5	32.1	.60	62.3
	5	28.2	.49	67.0	33.9	.66	60.0	39.5	.87	53.6
	6	34.2	.67	59.6	41.1	.93	51.6	47.9	1.20	43.7
	7	38.8	.84	54.3	46.6	1.21	45.2	54.4	1.78	36.0
NEW YORK No 5 CAPACITY = 74.45 CU. FT FREE AIR PER MINUTE	3	17.8	.31	76.1	21.3	.40	71.4	24.9	.50	66.5
	4	22.9	.44	69.2	27.5	.58	63.1	32.1	.75	57.0
	5	28.2	.61	62.1	33.9	.63	54.8	39.5	1.13	47.0
	6	34.2	.85	54.0	41.1	1.23	44.9	47.9	1.80	35.7
	7	38.8	1.09	47.8	46.6	1.67	37.5	54.4	2.72	27.0

MAKE AND CAPACITY OF AIR PUMP	BRAKE PIPE LEAKAGE IN LBS PER MIN. PRESSURE DROP	80 CAR TRAIN			90 CAR TRAIN			100 CAR TRAIN		
		VOL. FREE AIR IN BRAKE PIPE AT 70 LBS = 628.3 CU. FT.			VOL. FREE AIR IN BRAKE PIPE AT 70 LBS = 706.4 CU. FT.			VOL. FREE AIR IN BRAKE PIPE AT 70 LBS = 764.3 CU. FT.		
		LEAKAGE CU. FT. FREE AIR PER MINUTE	MINUTES TO PUMP BACK AIR LOST BY PRESS. DROP	PER CENT AIR OF PUMP AVAILABLE IN BRAKE PIPE	LEAKAGE CU. FT. FREE AIR PER MINUTE	MINUTES TO PUMP BACK AIR LOST BY PRESS. DROP	PER CENT PUMP AIR AVAILABLE IN BRAKE PIPE	LEAKAGE IN CU. FT. FREE AIR PER MINUTE	MINUTES TO PUMP BACK AIR LOST BY PRESS. DROP	PER CENT PUMP AIR AVAILABLE IN BRAKE PIPE
WESTINGHOUSE 9½" CAPACITY = 33.1 CU. FT OF FREE AIR PER MINUTE	3	28.5	6.10	13.9	32.0	29.1	3.33	35.6	BEYOND PUMP CAP'CTY	
	4	36.7	BEYOND PUMP CAP'CTY		41.2	BEYOND PUMP CAP'CTY		45.8	"	"
	5	45.2	"	"	50.7	"	"	56.4	"	"
	6	54.7	"	"	61.6	"	"	68.4	"	"
	7	62.2	"	"	70.0	"	"	77.7	"	"
WESTINGHOUSE 11" CAPACITY = 47.5 CU. FT OF FREE AIR PER MINUTE	3	28.5	1.50	40.0	32.0	2.06	32.7	35.6	2.99	25.1
	4	36.7	3.40	22.7	41.2	6.60	13.1	45.8	27.0	3.58
	5	45.2	15.6	4.84	50.7	BEYOND PUMP CAP'CTY		56.4	BEYOND PUMP CAP'CTY	
	6	54.7	BEYOND PUMP CAP'CTY		61.6	"	"	68.4	"	"
	7	62.2	"	"	70.0	"	"	77.7	"	"
WESTINGHOUSE 8½" COMPOUND CAPACITY = 85 CU. FT OF FREE AIR PER MINUTE	3	28.5	.50	66.5	32.0	.60	62.4	35.6	.72	58.2
	4	36.7	.76	56.9	41.2	.84	51.5	45.8	1.17	46.0
	5	45.2	1.13	49.8	50.7	1.48	40.3	56.4	1.97	35.6
	6	54.7	1.81	35.6	61.6	2.65	27.5	68.4	4.12	19.5
	7	62.2	1.73	26.8	70.0	4.66	17.6	77.7	10.6	8.6
NEW YORK No 5 CAPACITY = 74.45 CU. FT FREE AIR PER MINUTE	3	28.5	.62	61.8	32.0	.75	57.0	35.6	1.01	52.2
	4	36.7	.97	50.7	41.2	1.24	44.7	45.8	1.60	38.4
	5	45.2	1.54	39.3	50.7	2.14	31.8	56.4	3.13	24.3
	6	54.7	2.78	26.5	61.6	4.80	17.2	68.4	11.3	8.1
	7	62.2	5.08	16.4	70.0	15.7	6.0	77.7	BEYOND PUMP CAP'TY	

fective triple valves, are some of the main defects, and there is really no excuse for train and enginemen, who know of their existence, not reporting same. They do not do it, however; on the contrary, when the engineer, in trying to pump up his train, makes complaint that "there must be a leak somewhere," he is usually advised to "open up his pump a little more," and the investigation ends there. We have faith enough in the managers of railroads to say that if they knew as well as the trainmen and enginemen do the condition of the equipment on freight trains, there would soon be a reform in that line that would be a source of joy to all concerned. No one is in a better position to give them this information than the trainmen and enginemen. Why neglect this?

MISCELLANEOUS.

Water—One cubic inch weighs .036 pound. One cubic foot at 32° F. weighs 62.4 pounds and contains 7.4 United States gallons.

One gallon, United States standard, contains 231 cubic inches and weighs 8 1/3 pounds.

One gallon, Imperial, contains 277¼ cubic inches and weighs 10 pounds.

Coal—Average weight of one cubic foot:

Bituminous, large size	52 pounds.
Bituminous, run of mine	54 pounds
Anthracite, large size	54 pounds
Anthracite, buckwheat	52 pounds

Average weight of one bushel, containing 2,500 cubic inches:

Bituminous	75 pounds
Anthracite	78 pounds

Specific gravity:

Bituminous	1.40
Anthracite	1.60

Average bulk of one ton (2240 pounds):

Bituminous	43 cubic feet.
Anthracite	41.5 cubic feet.

Coal—Grade Divisions—

Anthracite, all coal with less than 7.5 per cent volatile matter in combustible.

Semi-anthracite, all coal with 7.5 per cent to 12.5 per cent volatile matter in combustible.

Semi-bituminous, all coal with 12.5 per cent to 25 per cent volatile matter in combustible.

Bituminous, all coal with 25 per cent to 50 per cent volatile matter in combustible.

Lignite, all coal with more than 50 per cent volatile matter in combustible.

Relative Heating Value of Fuels—

One pound of average soft coal possesses as much heating value, as fuel, as 2¼ pounds of average dry wood.

One pound of oil possesses nearly as much heating value as two pounds of average coal.

WEIGHT AND VOLUME OF CRUDE PETROLEUM.

Pound	U. S. Liquid Gal.	Barrel	Gross Ton
1.	.13158	.0031328	.0004464
7.6	1.	.02381	.003393
319.2	42.	1.	.1425
2240.	294.72	7.017	1.

Fuel Consumption—

Assuming that one-half stroke cut-off represents the average work of the cylinders for a given run, the water consumption will be about 25 pounds, or 3 gallons per horse-power per hour, and the consumption of coal about one pound per gallon of water, or 3 pounds per horse-power.

Rules for Driving Wheel Speed—

Revolutions per mile—Divide 1680 by the diameter of the driving wheel in feet. Revolutions per minute—Multiply the speed in miles per hour by 28 and divide the product by the diameter of the driving wheel in feet.

Piston Speeds—

Piston speed in feet per minute—Multiply revolutions per minute by twice the stroke of piston in feet.

LOCOMOTIVE TRACTIVE EFFORT.

Locomotive tractive effort is to be figured with the following formula, which is the latest ruling of the Interstate Commerce Commission:

Diameter of cylinder, squared, times stroke, times 85% of boiler pressure
Divided by diameter of driving wheel in inches.

HORSE-POWER OF A LOCOMOTIVE.

The term horse-power was first established by James Watt, who ascertained that a strong London draught horse was capable of doing work for a short interval of time equivalent to lifting 33,000 pounds one foot high in one minute.

This value was used by Watt in expressing the power of his engines, and has since been universally adopted in mechanics. The expression foot-pounds is used to denote the unit of work, and is the force required to lift a weight of one pound through a space of one foot.

Horse-power is the measure of the rate at which work is performed and is equal to 33,000 pounds lifted one foot in one minute, or one pound lifted 33,000 feet in one minute, or one pound lifted 550 feet in one second; therefore, one horse-power equals 550 foot-pounds per second.

The tractive power of a locomotive multiplied by the speed in miles per hour, divided by 375, gives the horse-power.

HEATING SURFACE OF BOILER TUBES.

Length In Feet	Heating Surface in Square Feet				L'gth In In.	Heating Surface in Square Feet			
	Outside Diameter					Outside Diameter			
	1½ In.	1¾ In.	2 In.	2¼ In.		1½ In.	1¾ In.	2 In.	2¼ In.
5	1.964	2.291	.....	.....	¼	0.008	0.009	0.011	0.012
6	2.356	2.749	3.142	.....	½	0.016	0.019	0.022	0.025
7	2.749	3.207	3.665	.....	¾	0.025	0.029	0.033	0.037
8	3.142	3.665	4.189	.....					
9	3.534	4.123	4.712	.....	1	0.033	0.038	0.044	0.049
10	3.927	4.582	5.236	5.891	2	0.066	0.076	0.087	0.098
11	4.320	5.040	5.760	6.480	3	0.098	0.115	0.131	0.147
12	4.712	5.498	6.283	7.069	4	0.131	0.153	0.175	0.196
13	5.105	5.956	6.807	7.658	5	0.164	0.191	0.218	0.245
14	5.498	6.414	7.330	8.247	6	0.196	0.229	0.262	0.294
15	5.891	6.872	7.854	8.836	7	0.229	0.267	0.305	0.344
16	.....	7.320	8.378	9.425	8	0.262	0.305	0.349	0.393
17	.....	.....	8.901	10.014	9	0.295	0.344	0.393	0.442
18	.....	.....	9.425	10.603	10	0.327	0.382	0.436	0.491
19	.....	.....	9.948	11.192	11	0.360	0.420	0.480	0.540
20	.....	.....	10.472	11.781	12	0.3927	0.4582	0.5236	0.5891
21	.....	.....	10.995	12.360					
22	.....	.....	11.519	12.959					

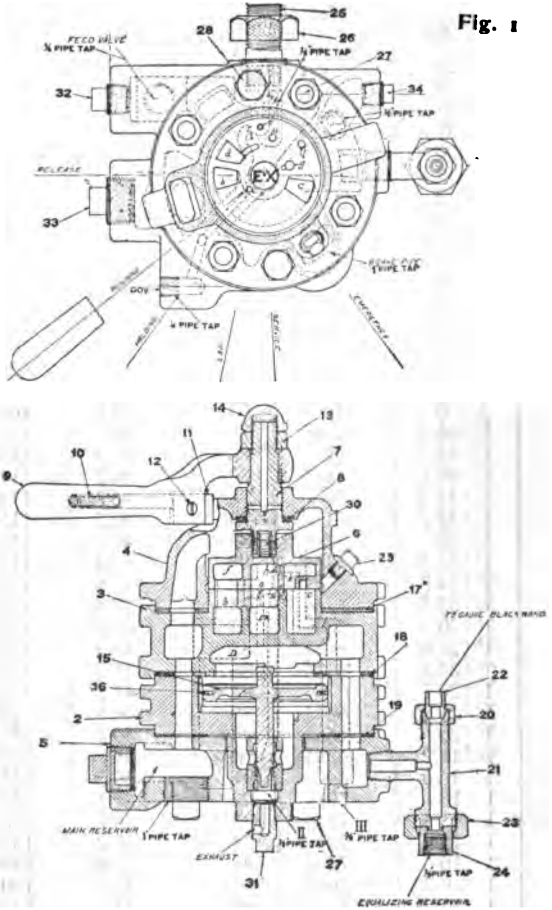
SPEED, SECONDS PER MILE; IN MILES PER HOUR.

Seconds Per Mile	Miles Per Hour	Seconds Per Mile	Miles Per Hour	Seconds Per Mile	Miles Per Hour	Seconds Per Mile	Miles Per Hour
24	150	54	66.6	84	42.8	114	31.6
25	144	55	65.4	85	42.3	115	31.3
26	138.5	56	64.3	86	41.8	116	31
27	133.3	57	63.1	87	41.3	117	30.7
28	128.5	58	62	88	40.9	118	30.5
29	124.1	59	61	89	40.4	119	30.2
30	120	60	60	90	40	120	30
31	116.1	61	59	91	39.5	121	29.7
32	112.5	62	58	92	39.1	122	29.5
33	109	63	57.1	93	38.7	123	29.2
34	105.8	64	56.2	94	38.3	124	29
35	102.8	65	55.3	95	37.9	125	28.8
36	100	66	54.5	96	37.5	126	28.6
37	97.3	67	53.7	97	37.1	127	28.3
38	94.7	68	52.9	98	36.7	128	28.1
39	92.3	69	52.1	99	36.4	129	27.9
40	90	70	51.4	100	36	130	27.7
41	87.8	71	50.7	101	35.6	132	27.2
42	85.7	72	50	102	35.3	134	26.8
43	83.7	73	49.3	103	34.9	136	26.4
44	81.8	74	48.6	104	34.6	138	26
45	80	75	48	105	34.3	140	25.7
46	78.2	76	47.3	106	34	142	25.3
47	76.6	77	46.7	107	33.7	144	25
48	75	78	46.1	108	33.4	146	24.6
49	73.4	79	45.5	109	33	148	24.3
50	72	80	45	110	32.7	150	24
51	70.5	81	44.4	111	32.4	152	23.6
52	69.2	82	43.9	112	32.1	154	23.3
53	67.9	83	43.3	113	31.8	156	23.1

SPEED, TIME PER MILE, FEET PER SECOND.

Miles Per Hour	Time Per Mile		Feet Per Second	Miles Per Hour	Time Per Mile		Feet Per Second
	Min	Sec.			Min.	Sec.	
8	7	30	11¾	58	1	2.1	85
15	4	0	22	59	1	1	86½
16	3	45	23½	60	1	0	88
17	3	31.8	25	61		59	89½
18	3	20	26½	62		58	91
19	3	9.5	28	63		57.1	92½
20	3	0	29¼	64		56.2	94
21	2	51.4	30¾	65		55.4	95¼
22	2	43.6	32¼	66		54.5	96¾
23	2	36.5	33¾	67		53.7	98¼
24	2	30	35¼	68		52.9	99¾
25	2	24	36¾	69		52.1	101¼
26	2	18.5	38¼	70		51.4	102¾
27	2	13.2	39½	71		50.7	104¼
28	2	8.6	41	72		50	105½
29	2	4.1	42½	73		49.3	107
30	2	0	44	74		48.6	108½
31	1	56.2	45½	75		48	110
32	1	52.5	47	76		47.3	111½
33	1	49.1	48½	77		46.7	112¾
34	1	45.8	50	78		46.1	114¼
35	1	42.7	51¼	79		45.5	115½
36	1	40	52¾	80		45	117
37	1	37.3	54¼	81		44.4	118¾
38	1	34.8	55¾	82		43.9	120¼
39	1	32.3	57¼	83		43.4	121¾
40	1	30	58¾	84		42.8	123¼
41	1	27.8	60¼	85		42.3	124¾
42	1	25.7	61½	86		41.8	126¼
43	1	23.7	63	87		41.3	127¾
44	1	21.8	64½	88		40.8	129
45	1	20	66	89		40.4	130½
46	1	18.2	67½	90		40	132
47	1	16.6	69	91		39.5	133½
48	1	15	70½	92		39.1	135
49	1	13.5	71¾	93		38.7	136½
50	1	12	73¼	94		38.2	137¾
51	1	10.6	74¾	95		37.8	139¼
52	1	9.2	76¼	96		37.5	140¾
53	1	7.9	77¾	97		37.1	142¼
54	1	6.7	79¼	98		36.7	143¾
55	1	5.5	80¾	99		36.4	145¼
56	1	4.3	82¼	100		36	146½
57	1	3.2	83½	101		35.6	148¼

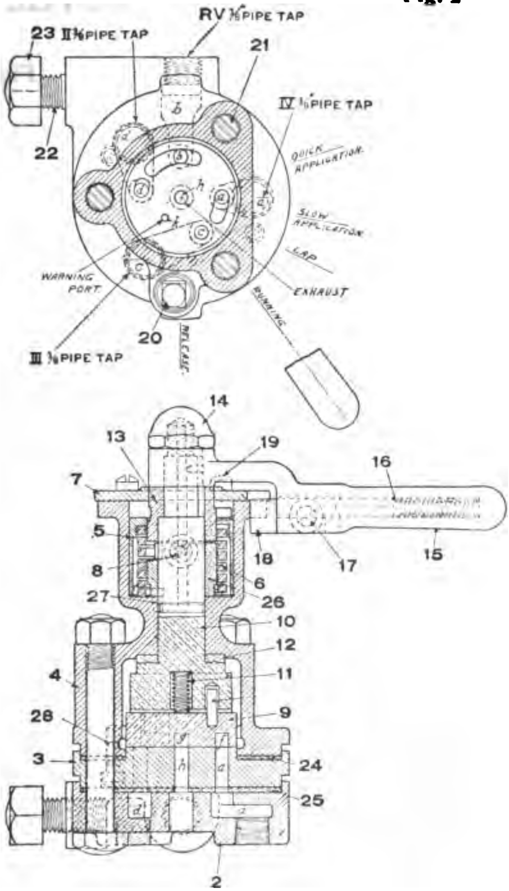
Fig. 1



THE H-6 AUTOMATIC BRAKE VALVE

WESTINGHOUSE

Fig. 2

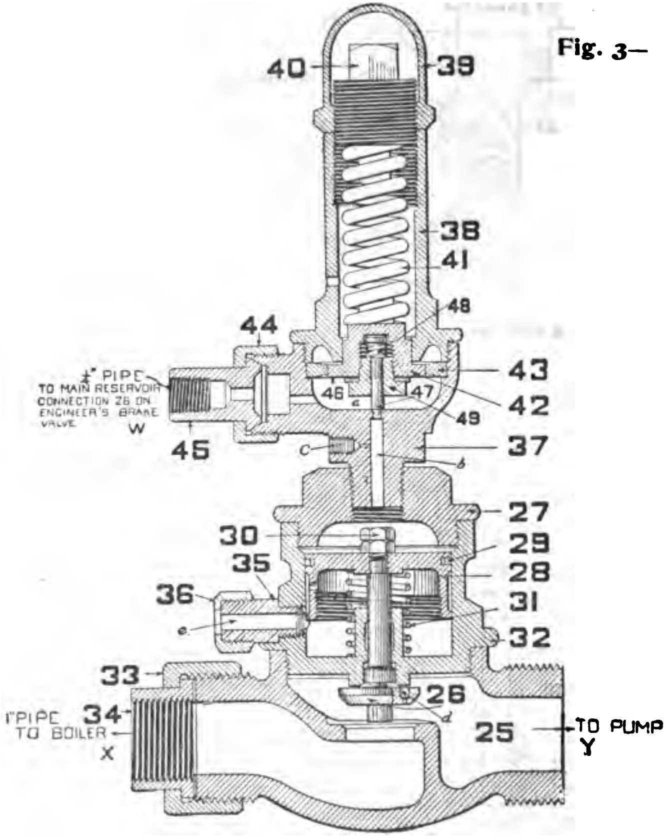


THE S-6 INDEPENDENT BRAKE VALVE

Westinghouse

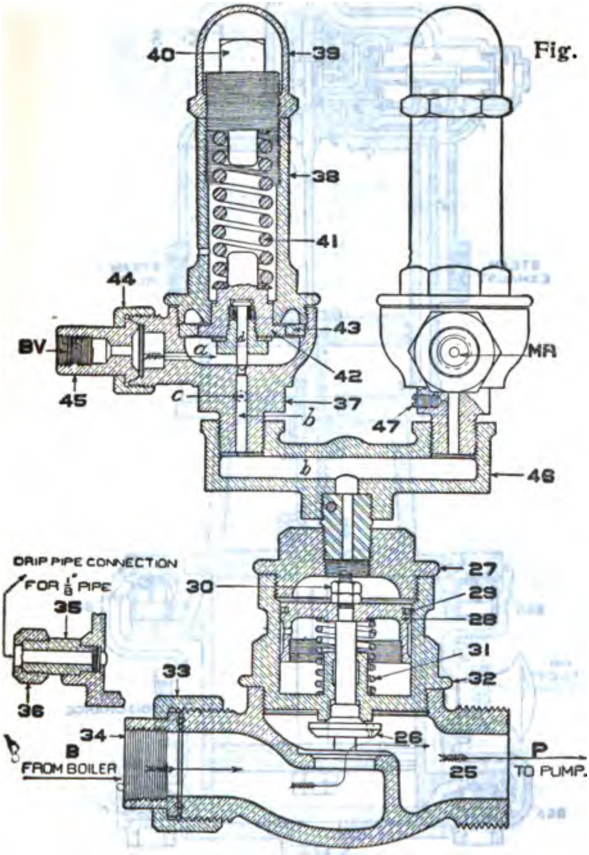
WESTINGHOUSE AIR PUMP GOVERNORS.

Fig. 3—



AIR PUMP GOVERNOR—SINGLE.

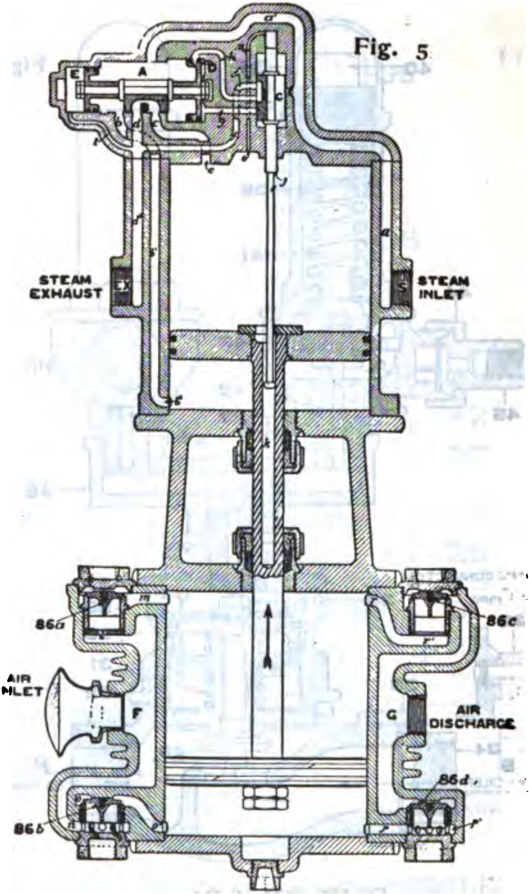
Fig. 4—



DUPLEX GOVERNOR

WESTINGHOUSE AIR PUMPS.

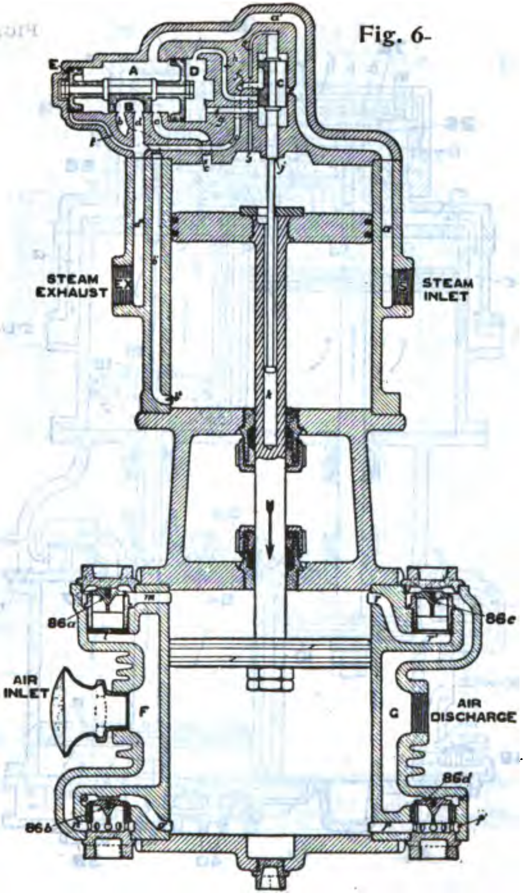
Fig. 5



Upward stroke

WESTINGHOUSE AIR PUMPS.

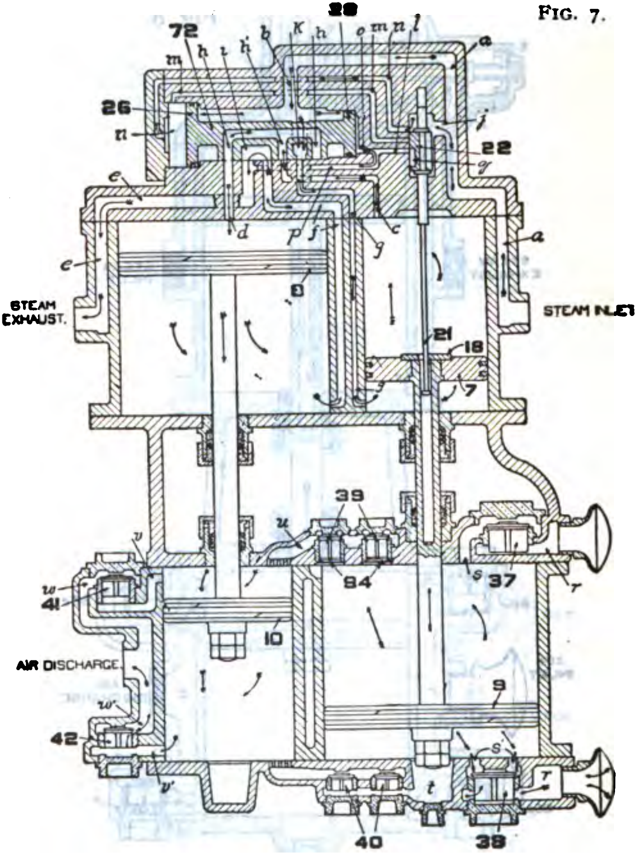
Fig. 6-



Down stroke

WESTINGHOUSE AIR PUMPS.

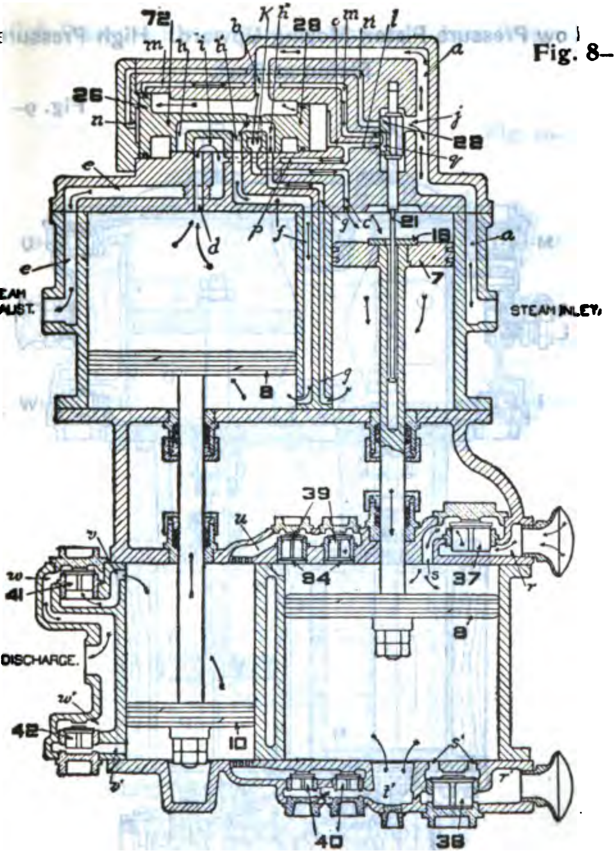
FIG. 7.



Upward stroke

WESTINGHOUSE AIR PUMPS.

Fig. 8–

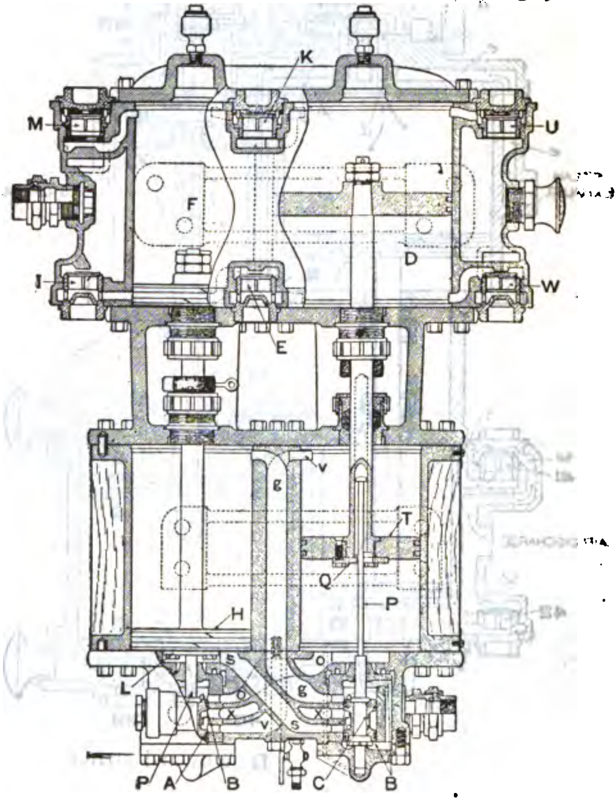


Downward stroke

NEW YORK DUPLEX AIR PUMP.

Low Pressure Piston Moving Upward. High Pressure Piston at Rest.

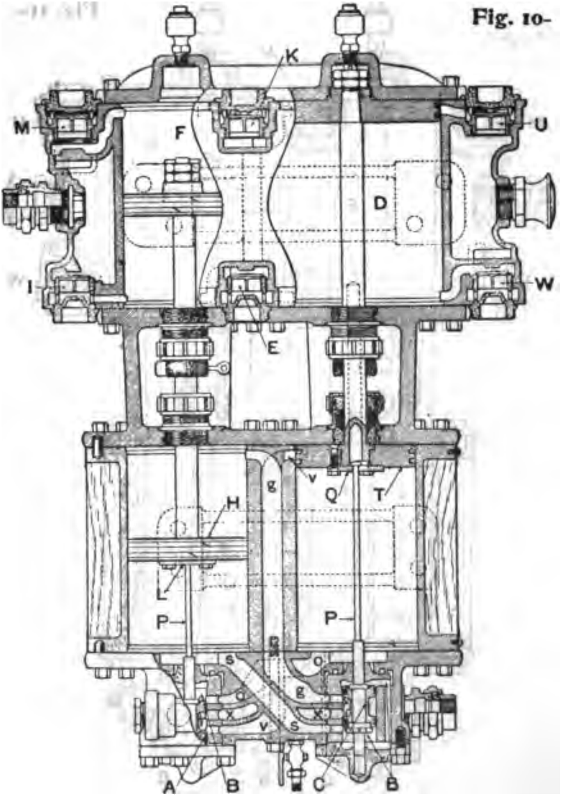
Fig. 9–



NEW YORK DUPLEX AIR PUMP.

High Pressure Piston Moving Upward. Low Pressure Piston at Rest.

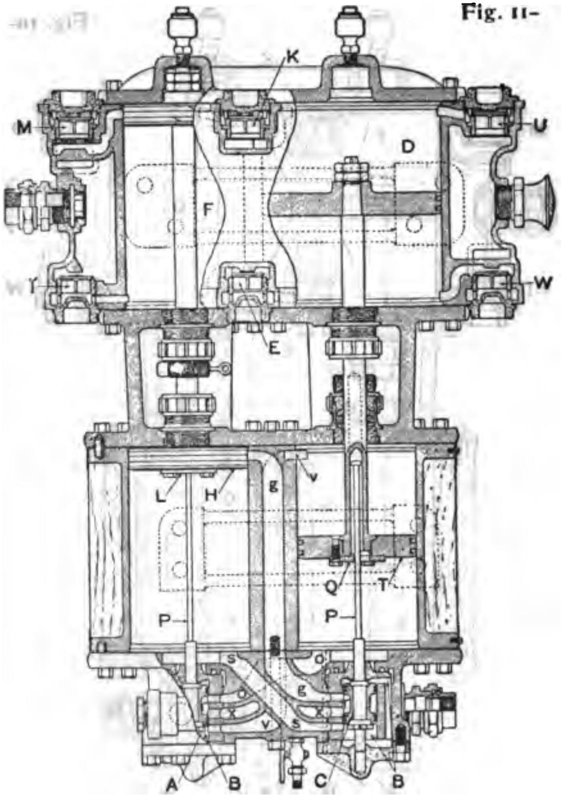
Fig. 10-



NEW YORK DUPLEX" AIR PUMP.

Low Pressure Piston Moving Downward. High Pressure Piston at Rest.

Fig. 11-



High Pressure Piston Moving Downward. Low Pressure Piston at Rest.

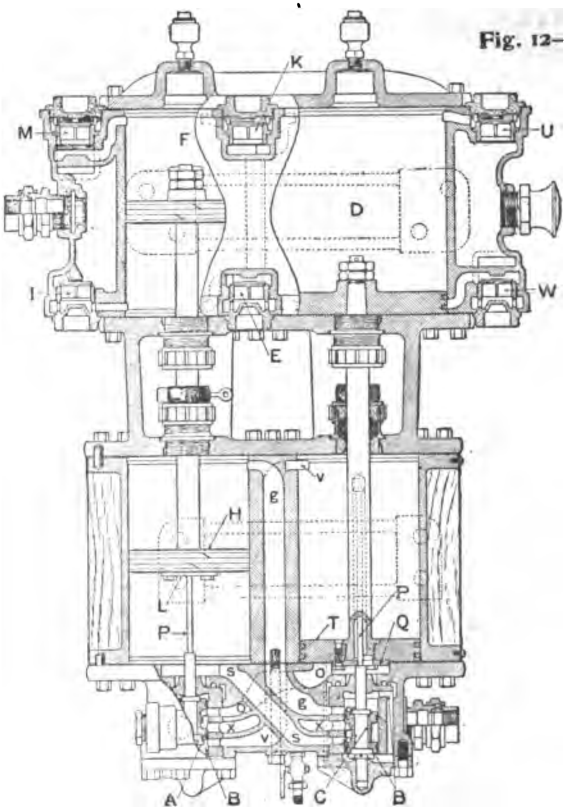


Fig. 12-

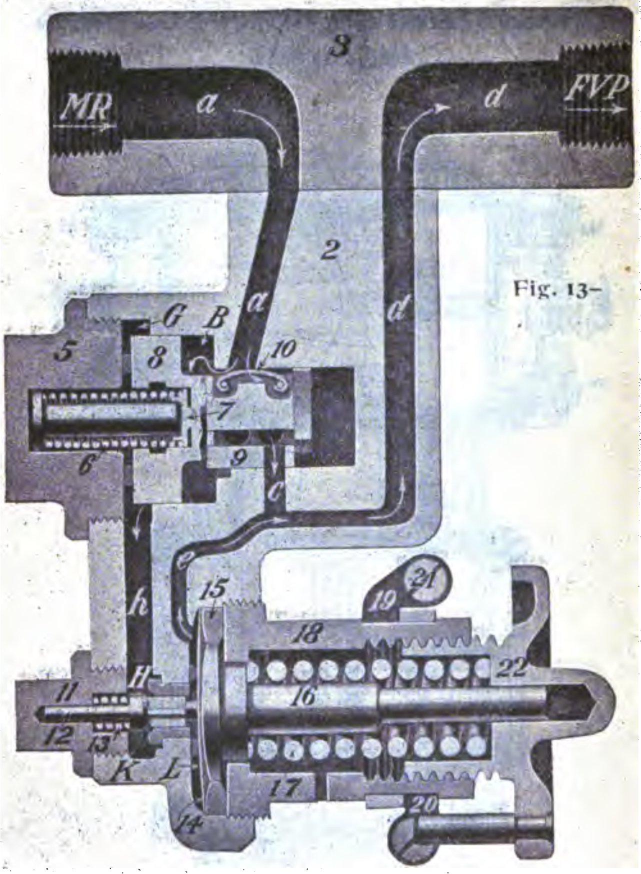


Fig. 13—DIAGRAM OF B-6 FEED VALVE, OPEN

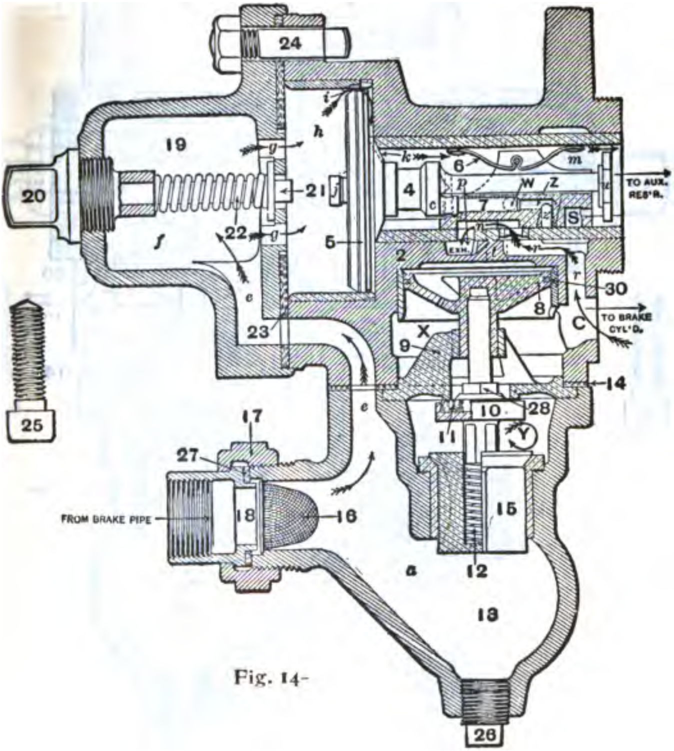


Fig. 14-

Full Release and Charging Position.

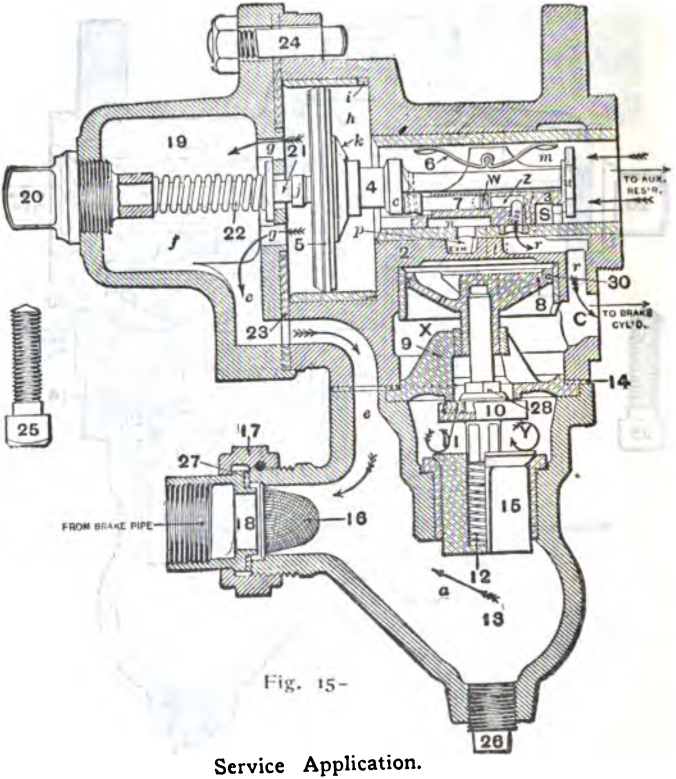


Fig. 15-

Service Application.

WESTINGHOUSE TRIPLE VALVES.

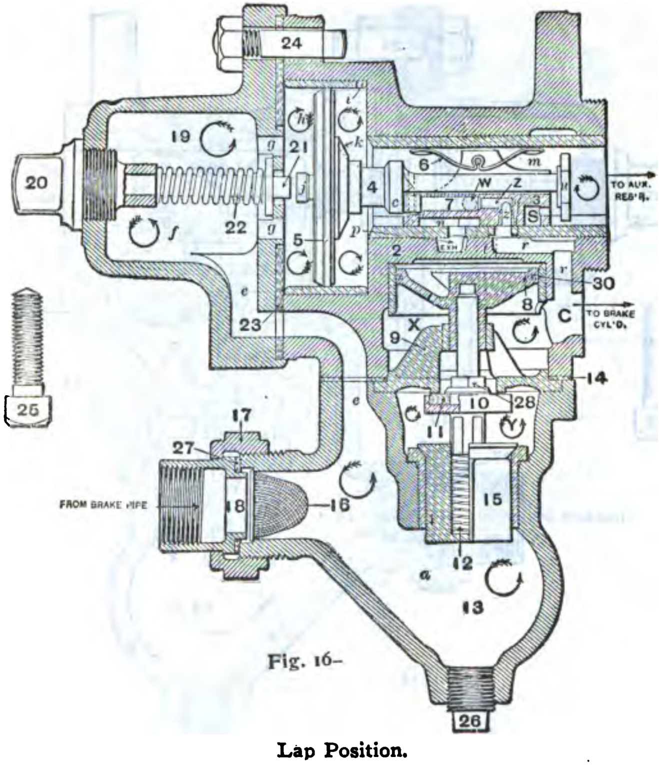


Fig. 16–

Lap Position.

WESTINGHOUSE TRIPLE VALVES.

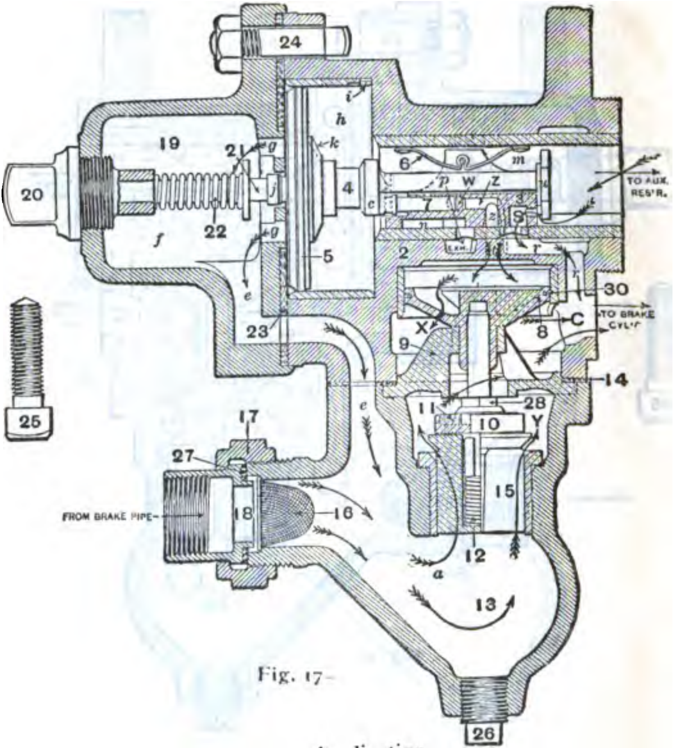


Fig. 17

Emergency Application.

N. Y. QUICK ACTION TRIPLE VALVES.

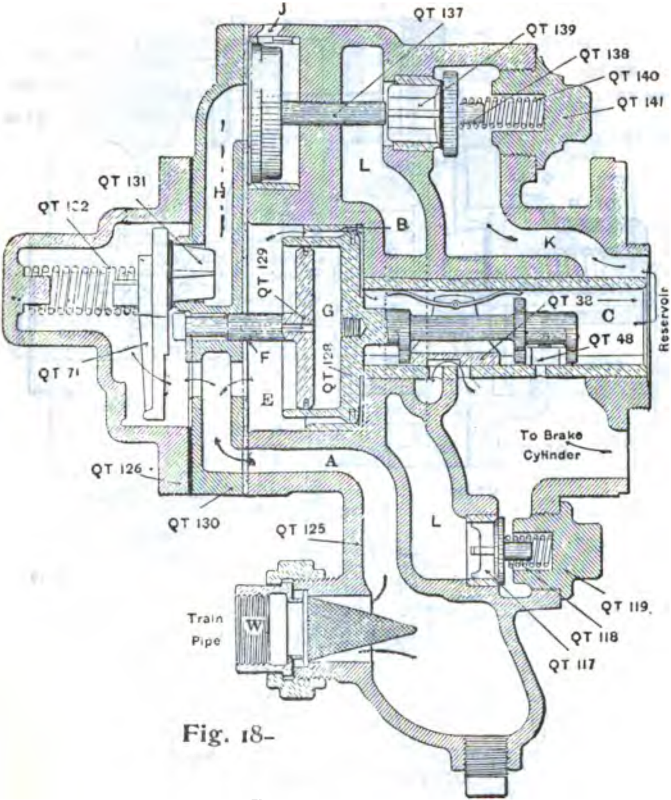


Fig. 18-

Release. Recharging Running Position.

N. Y. QUICK ACTION TRIPLE VALVES.

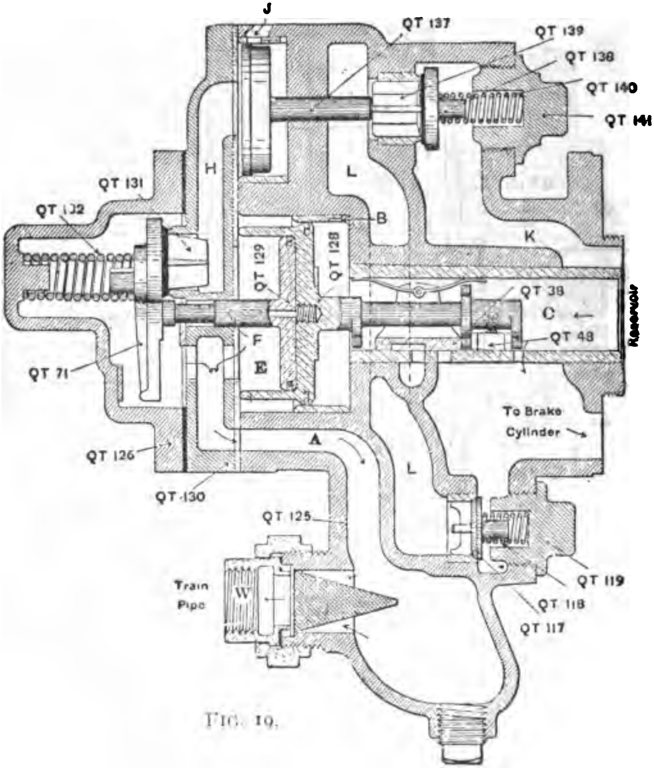


FIG. 19.

Service Application.

N. Y. QUICK ACTION TRIPLE VALVES.

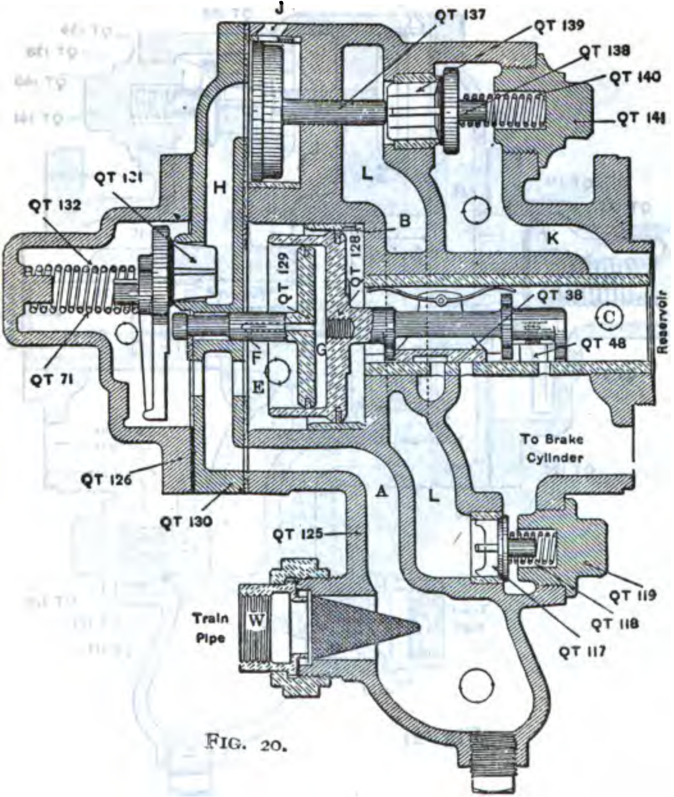


FIG. 20.

Lap Position.

N. Y. QUICK ACTION TRIPLE VALVES.

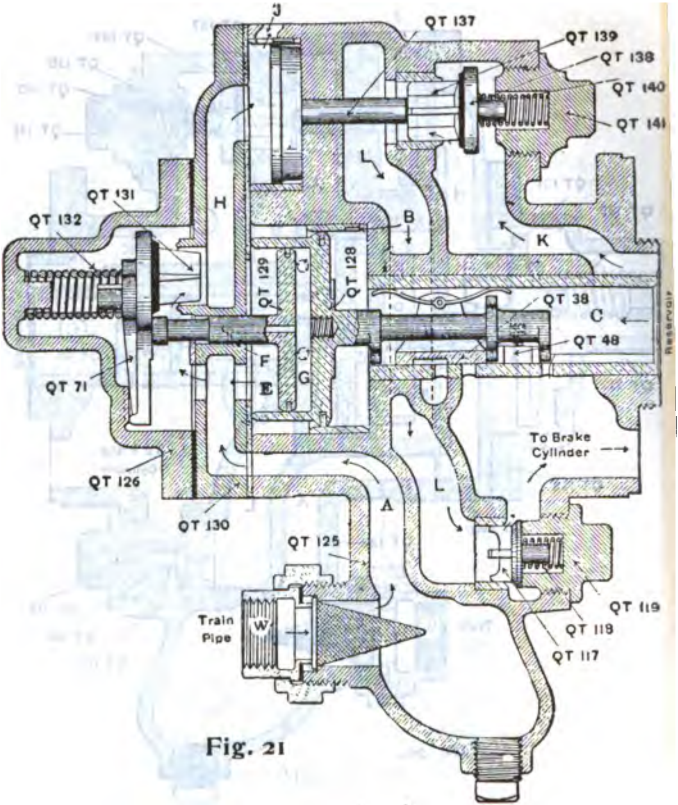


Fig. 21

Emergency Application.

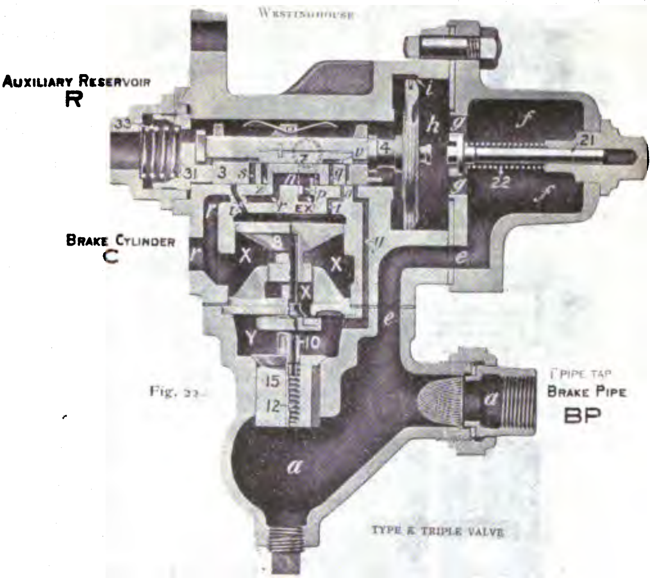


Fig. 22.

TYPE K TRIPLE VALVE

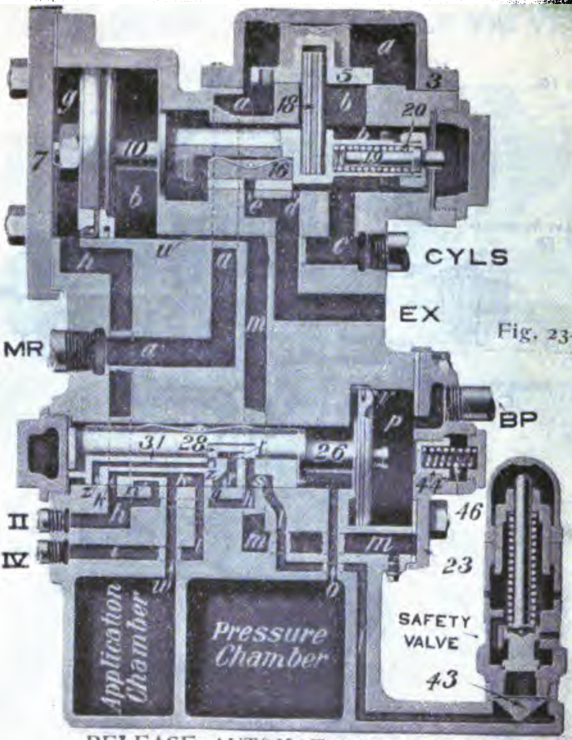


Fig. 23—RELEASE, AUTOMATIC OR INDEPENDENT

CONNECTIONS:

MR—MAIN RESERVOIR PIPE; IV—DISTRIBUTING VALVE RELEASE PIPE; II—APPLICATION CYLINDER PIPE; CYLS—BRAKE CYLINDER PIPE; BP—BRAKE PIPE

NEW YORK Automatic Control Valve.
Full Release.

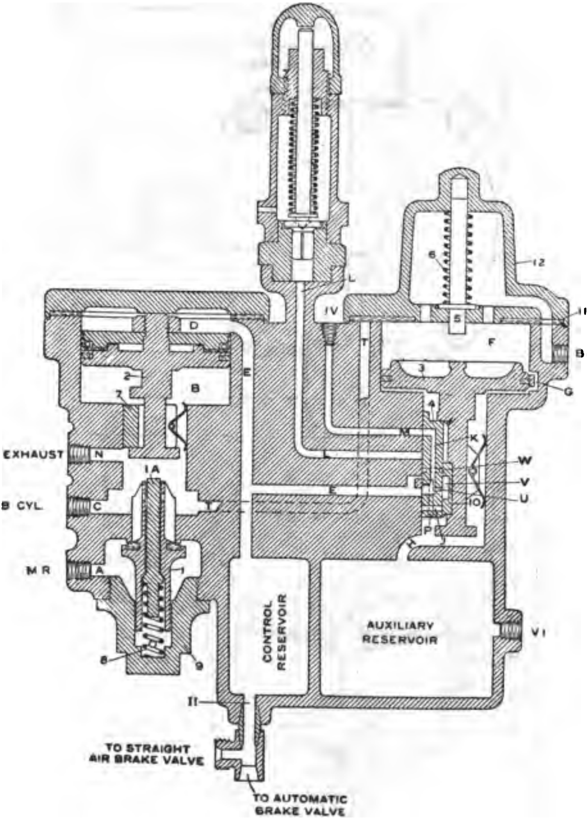
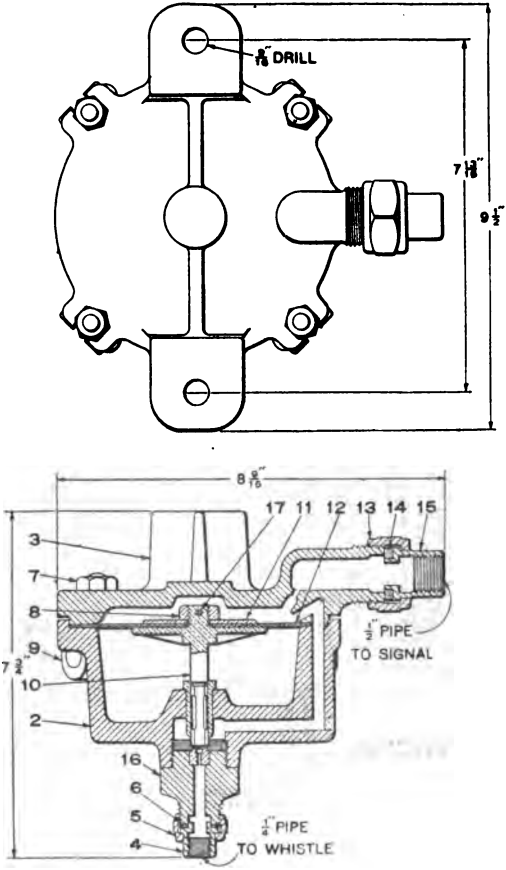


Fig. 24–

Fig. 25



WHISTLE SIGNAL VALVE

WESTINGHOUSE

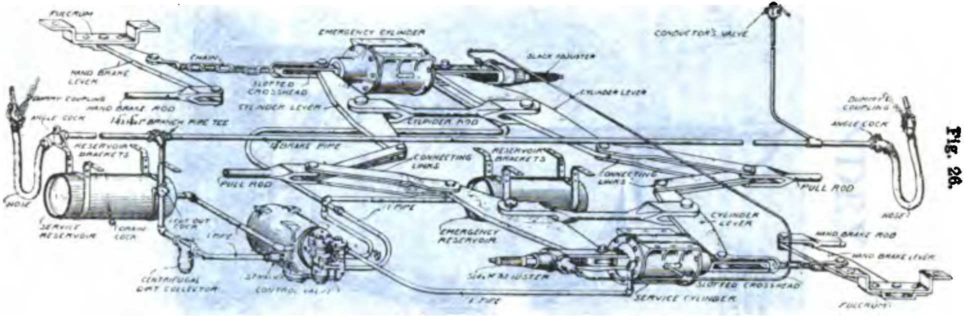


Fig. 26.

-PC Passenger Brake Equipment. Cylinders Pointing in Opposite Directions.

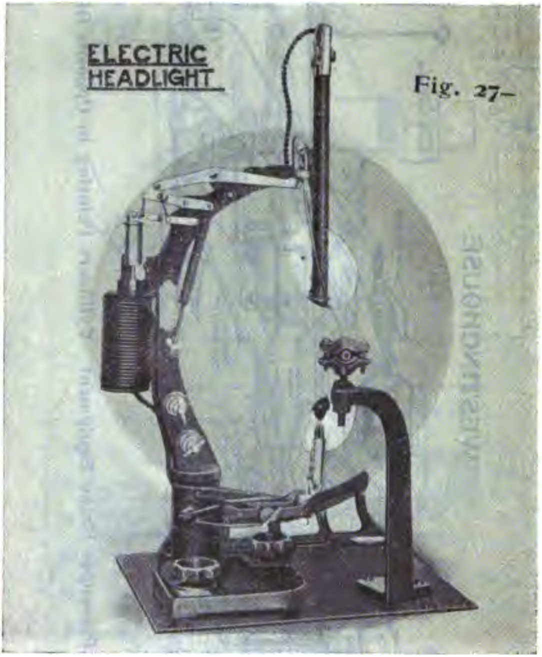


Fig. 27–

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